
SURVEY OF INDIA
A SETU
HIMACHALAM

Plate 1

INDIA

NORTH OF HYDERABAD

1864

Scale 128 Miles = 1 Inch.

Miles 100 140 130 100 80 60 40 20 0 160 320 Miles

Surveyor General of India.

REFERENCES

British States colored Pink

Dependent & Subordinate Native States Yellow

Independent States Green

Railways opened

" not opened

Roads Red

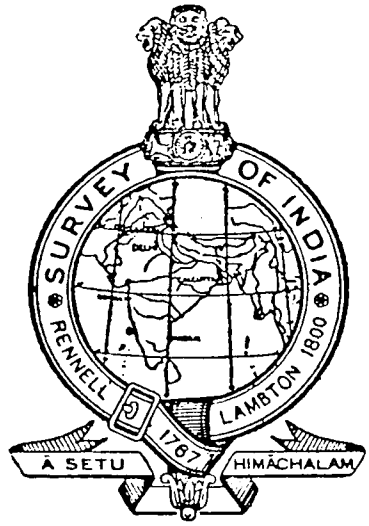
Telegraph Stations

Printed at the Survey of India Offices (H.L. O.)

HISTORICAL RECORDS OF THE SURVEY OF INDIA

Volume V
1844 to 1861
ANDREW WAUGH

Collected and compiled by
Colonel R. H. PHILLIMORE, C.I.E., D.S.O.,
(Late Royal Engineers and Survey of India)



PUBLISHED BY ORDER OF
THE SURVEYOR GENERAL OF INDIA

PRINTED AT THE SURVEY OF INDIA OFFICES, 103 (P.Z.O.)
PRINTING GROUP, DEHRA DUN (U.P.), INDIA
1968

Price Rupees Fortyfive

© *Government of India Copyright 1968.*

SURVEY MAXIMS

However apparently valueless the country, ... a knowledge of...a country is the first step to improvement and...must be based on good maps [168].

ANDREW WAUGH.

Where the conditions requisite to ensure accuracy are not carried out, errors will be generated and accumulation of error must be expected [286].

ANDREW WAUGH.

Sound training in the first instance, and vigilant inspection afterwards, are essential to the success of all great undertakings. in every country [290].

ANDREW WAUGH.

Neither the Himalaya snows, nor arid deserts, nor dense unhealthy jungle, nor hostilities, ... have been allowed to arrest the progress of surveys in our time [283].

ANDREW WAUGH.

Nothing is impossible which has not been tried [205].

ANDREW WAUGH.

Surveying is a profession which requires exclusive devotion to achieve much above mediocrity [143].

ANDREW WAUGH.

Working out traverses with logarithms or...tables is neither an exhilarating or interesting occupation, but it is unfortunately a work which all revenue surveyors are at times obliged to do [265].

DONALD VANRENEN.

As time rolls by people forget, after elaborate and expensive surveys have been made, ... that the old document was good in its generation, and correct to the extent of information then procurable [317].

HENRY THUILLIER.

The sub-assistants of the Great Trigonometrical Survey... would...make every personal sacrifice for the honour and success of the Department. ... No class of men in India go through more hardships and privations, and none are more cheerful, well disposed, obedient and loyal [409].

ANDREW WAUGH.

VOLUME I 18th Century Published 1945.
VOLUME II 1800–15 „ 1950.
VOLUME III 1815–30 „ 1954.
VOLUME IV 1830–43 George Everest „ 1958.

VOLUME V

Published 1968

PRINTED IN INDIA

Sketch Map

OF THE

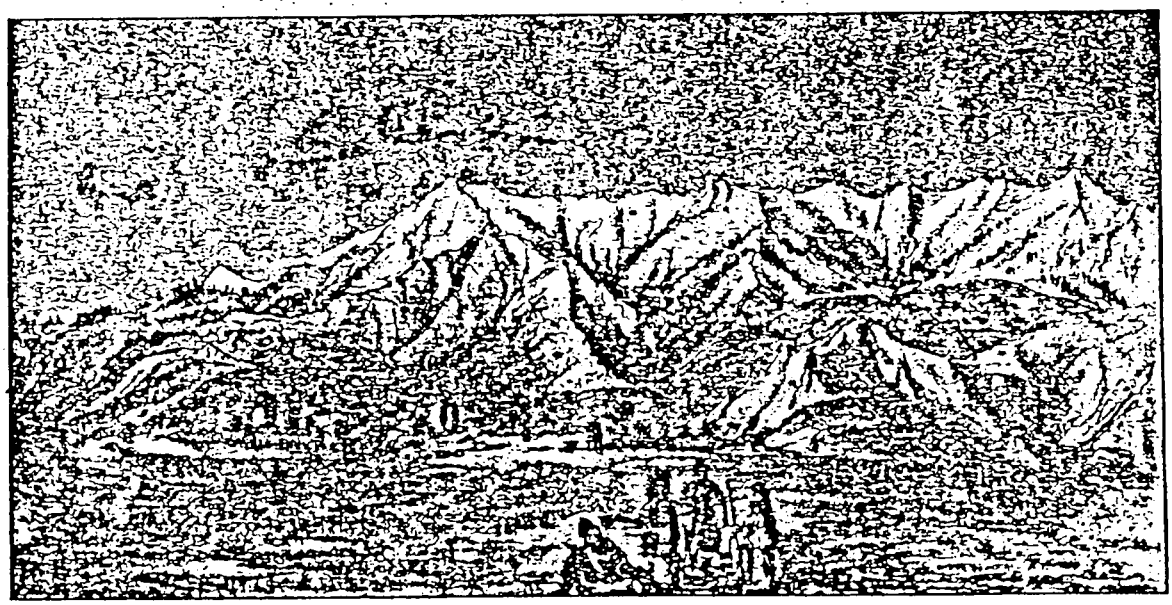
Road between THULL *and* CHUZNEE

showing the Route by the PAIWAR KOTHUL

and down the SHOOTURGURDUN *through* LOGUR

SCALE

Reduced from Four Miles to One Inch.



Sketch of the Sufeidkoh Range from the village of Hubeeb Killa

A- Summit of Paiwar Pass

B- Dº Speenghowy pt

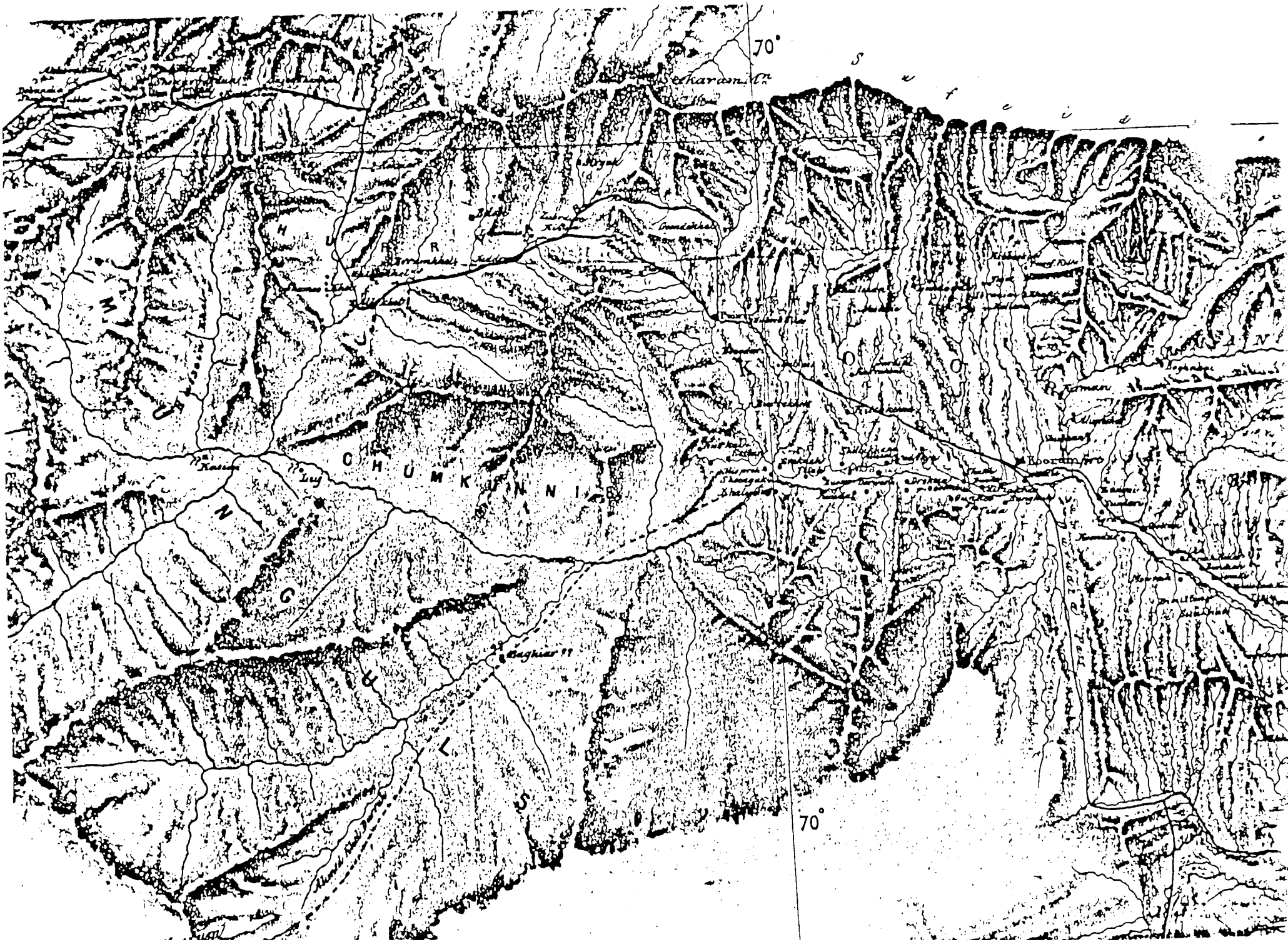
C- Village of Paiwar.

D Sikaram Mountain.

P. Lumsden Lieut-

Kandahar Injrs

January 15th 1858.


70°
70°
Serkaron
Boyuk
Zubr
Kiel
Kaman
Kaman
Kaman

ADDENDA & CORRIGENDA, VOL. II

Supplementary to lists on p. xiii of Vol. II, pp. v to vii of Vol. III, and p. v of Vol. IV.

Page

xxiv against Plate 11, *del.* & Ceded Districts.

xxvi below *As R.* enter *BM. Cat. MS. Catalogue of MS. Maps in the British Museum*, 1861.
BM. Cat. Pr. Catalogue of Printed Maps in the British Museum.
below Buchanan *enter* Bullock
Historic Delhi. Humphry Bullock, Delhi, 1951.
Burkill *Chapters on the History of Botany in India*, I to III. I. H. Burkill. *Journal of the Bo. Nat. Hist. Soc.* vols. 51, Dec. 1953 ; 54, Dec. 1856 ; 58, Dec. 1961.

xxvii *below* Geo. Everest *insert Geo. Mag.*
Geographical Magazine, London, monthly from 1874.
col. 2, *against* Izzut Oollah; *at end of the line 1 read* Izzut.

xxviii col. 2, *against* Thackeray, *for* Notes *read* Notices ; *below* Williams *insert* Williams, G. R. C.
Historical & Statistical Memoir of Dehra Doon. G. R. C. Williams, BCS., Roorkee, 1874.

13 to n.7 *add* Fleming's fdbks., *IO Cat.* (157) ; 1-inch map ; ib. (191).

17 to n.4 add ; *IO Cat.* (196–7), Morrieson's svys. 1811–5, tr. from IO. to India, 1924.

23 to n.9, as amended IV (v), *after* Blunt *add* *IO Cat.* (111, 181).

24 at end of note 1, *add* ; Sackville's maps, MRIO. 55 (12–4, 38) ; 56 (2).

25 n.3, amended III (vi), *for* 180 *read* 180–1.

33 to n.4, add ; *IO Cat.* (210, 226)
to n.6, amended IV (v), add ; *IO Cat.* (210), routes 1808.
at end of para 4 from bottom, *after* 1812, *insert ref. to new note*, to read ; *IO Cat.* (226).

35 to n.6 add ; *IO Cat.* (217), Blake's fdbk.

36 n.3, line 2, *for* 38 *et seq read* 36–9.

37 to n.10 amended III (vi), add ; *IO* (210), routes of 1812.

45 to n.10 add ; *IO Cat.* (210), map of S. frontier.

46 n. 2, line 2, *before* BSC., *insert* ; *IO Cat.* (201), Smyth's svy. ; to n.3, *IO Cat.* (201), Raper's svy.

50 n. 1, *del.* elsewhere *and* after *Keta* insert *IO Cat.* (265).

65 *under section* ELPHINSTONE'S MISSION, *para 1, line 5, after* Kashmir *insert ref. to new note, to read*
Afghāns held Kashmir 1752 to 1819.
to n.7, *add* ; Macartney's routes, *IO Cat.* (259) ; *Ocean Highways* (207).

66 at end of para 2 from bottom, *after* critical *enter semi-colon.*
to n.4 add ; *IO Cat.* (478), Macartney's map of Kingdom of Kabul, 1809 ; revised, London, 1838.
to n.8 add ; *IO Cat.* (234–5), Tickell's routes.
to n.15 *add* ; Memoir on Map of Afghanistan, *IO Cat.* (473–4).

70 para 8, line 4, *before* pl. 8 *inside bracket, insert* 71 n.2.

71 n.2, *before* MRIO. *insert IO Cat.* (467–8), and to n.10 *add* ; Snow Mountains laid down Nathpur to Moradābād, *IO Cat.* (468).

79 at end of para 1, *after* Ganges *add* [1 : 72–3].

80 at end of para 3, *after* Ludiana *add IO Cat.* (354).

87 at end of para 6 from bottom *after* peak *add* [v, 83].

94 n.3, line 2, *after* 222 *insert IO Cat.* (296) ; *and to n.5, add* ; road svys. N. of Bangalore, 1801, J. Colebrooke, *IO Cat.* (295).

95 notes 6, 7, 8, for 00 read 1800 ; to n. 8, add ; Arthur's svy., 1800, *IO Cat.* (295).

98 to n. 7, add ; svy. of N. frontier of Mysore, 1801, *IO Cat.* (296).

101 n.5, *before* Map *insert* 1-inch, *and after* Map *insert IO Cat.* (297).

Page

102 to n.6, *add* ; Morison's svy. of Nagamungalam 1803, *IO Cat.* (295).

109 to n.2, add ; *IO Cat.* (395), Canara, N. Div., B.S. Ward, 1806, 1-inch to m.

112 to n.5, *add* ; Memoirs, 5 vols., 1808, *IO Cat.* (292–3) ; maps, 1802–8, ib. (293–5) ; Mysore & Ceded Dists., 1815, ib. (320).

129 to n.6 add ; *IO Cat.* (391), S. Arcot, 4-m. to inch, 1805–14.

137 to n.6, *add* ; Everest's Java Journals, *IO Cat.* (579).

138 to n.5 add ; *IO Cat.* (519), Baker's Java memoirs.

141 pl. 13, to last note *after* original *add IO Cat.* (357), MRIO. 3–PT–15.

155 n.8, as amended III (vi), before *IO Cat.* (33) *insert* trgn. *and at end add* ; 4-m. dist. maps, *IO Cat.* (320–1, 415).

169 at beginning of n.4, *before* Memoir, *insert* Hardy's 6½-m. map, *IO Cat.* (454) ;

173 to n.5, add ; *IO Cat.* (416) ; Kathiawar, Cutch & part of Gujarat in 13 sheets, ib. (454).

174 n.2, *before* Journal *insert* Sketch, *IO Cat.* (482).

176 to n.3, add ; *IO Cat.* (485) ; 10-m. map of Azerbaeejan, etc., Sutherland, 1808–9.

196 to n.6, add ; *IO Cat.* (623–4), obsns. by Goldingham.

274 para 4 from bottom, at end of line 5, *after* Mysore, *insert ref. to new note to read* ; Mackenzie's routes & maps, 1792 to 1802, *IO Cat.* (318–9).

275 line 2 of para 5 from bottom, *against* pl. 11 *insert ref. to new note to read* incl. MRIO. 135 (55a) ; Mysore Dominions, presented by Mackenzie to Mark Wilks, Madras, 22–10–1808.

285 to n.3 add ; *IO Cat.* (84–5), 11 sheets unfinished 1807 ; 9 sheets, issued 1821.
to n.9, add ; *BM Cat. Pr.* 52415 (18).

287 para 2 from bottom, line 2, *after* 1816 *insert ref. to new note to read* 16 m. to inch, 9 sheets, 1816, *IO. Cat.* (85).

316 to n.3 add ; *IO Cat.* (354), svy. of Madras & Environs., Dec. 1805 to April 1806.

380 col. 2, to para 3, *after* Cochin *insert* ; *IO Cat.* (414).

381 col. 2, *insert new line 6* ; Dec. 1805, svy. of St. Thomé, Madras, *IO Cat.* (354) [316].

382 col. 2, *under* BLAKE *insert new line 5*, m. c. 1806, Elizabeth Lidington *to old line 5 after* (622) *add* IV (638, v).

383 col. 1, *under* BLANE, *line 7, for* 632 *read* 322, *and add* ; Conolly (85/92).
at end of line 14, *after* (311), *add* ; *IO Cat.* (196).
at end of line 5 from bottom, *after* canal *add* *JASB.* II, 1833 (112–4).

384 col. 1 *under* BUCHANAN *at end of line 7 add* Burkill, I (865–6). *line 11 before* 1800 *enter* From May *lines 14–5, del.* compiled and
to n.4, *add* ; *IO Cat.* (169) ; dist. maps, c. 1814.

386 col. 1, under COLEBROOKE, Henry Thomas *at end of line 12 add* Burkill, I (863 4) *at end of line 18 add* interested in Botany.
last line *after* (pl. 11), *insert IO Cat.* (295).
col. 2, under COLEBROOKE R.H. *after line 18, insert para.*
A nephew, also Robt. Hyde, son of SG.'s 2nd son, Ulrich (1804–28), was b. 1827...Ens. Bo. Inf. 1846...Asst. Rev. Survr. Ahmadnagar, 1848...dr. nr. Poona, 3–10–49 [v, 494].

392 col. 2, *under* CRAWFORD, *para 5 from bottom, line 6. read* mission.

397 col. 1, *under* FLEMING, *line* 12, *after* 723, *add, inside bracket* 777.

Addenda & Corrigenda, Vol. II

Page
402 to n. 6, *add* ; *IO Cat.* (624), ms. obsns., 1821.
403 *under* Grindlay *for* 16 m. map *read* Map of India.
405 col. 1, *under* Heyne, *insert new line 2,*
b. 1–1–1770, at Doebra, nr. Pirna, Germany.
to line 4, after birth, *add* . ed. Dresden.
line 7, *after* FLS. *insert* 1813 *and after* (143) *add* ; Burkill, I (857–8).
Insert new line 8. Sailed Copenhagen Sept. 1790; arrd. Tranquebar [E. Coast pl. 1] 11–1–1792.
406 col. 2, para 3 from end of Heyne, line 1, *del.* granted.
line 3, after 2 years. *for* Asked to be *read* and Arrd. Madras 30–3–15.
to n.6 *add* Sold at Sotheby's, London 17–1–1956, water-colour drawings of Indian plants from Heyne's colln.
411 col. 1, *under* Lambton, *line 4, after* 1794 *insert*; 33rd Ft. 3–5–1794, *and at end of line 5 add* ; to ½-pay, 33rd Ft. 25–12–18.
418 col. 2, at end of last para *under* McCarthy, *after* [12], *add* ; plans of Georgetown, 1807–8, 1814.
429 col. 2, at end of last line *under* Maxfield, *after* Calcutta *add* 1821, as Dep. Mar. SG., survd. Coromandel Coast, Pulicat to Armagaon shoals. *MRO.* 6/38.
430 col. 1, *under* Monteith, line 9 from bottom, *before* MRIO. *insert, IO Cat.* (485–6).
col. 2, *under* Moorcroft, line 2, *against* 1765 *insert ref. to new note, to read* from *DNB.*; the date 1786 [III, 485] would be too late, whilst date 1770 from *Ency Brit.* is more probable.
line 7, *after* xlvii. *insert* ; *Geo Mag.*, Aug. 1959 (204–14), with sketches from IO.
para 3 from bottom; line 6, *for* 30–1 *read* 80–1.
431 *at end of n.3 add* ; Moorcroft brought back a bundle of dried plants that were sent to London.
433 col. 1, at end of last line *under* Munro, *after* Gen.; *add* ; 1820 till death, Govt. of Madras.
435 col. 2, *under* Olliver, line 2, *read* b. c. 1784/86.
d., Barrackpore, 1–11–53.
to last line of page *add* ; *IO Cat.* (268).
436 col. 1, at end of last line *under* Paton, *after* sepia, *add* ; *IO Cat.* (265) [III, pl. 2].
col. 2, *under* Pickersgill, *line 9, after* (526) *add* IV; (6380).
438 col. 2, to last line *under* Ravenshaw, *after* Sessions. *add*; *IO Cat.* (354).
442 col. 2, *under* Smith, *line 5 from bottom, after* PWI., insert *Times* 23–11–1953; sold at Hodgson's, London, 10 aquatint views of PWI. by Wm. Daniell after Robt. Smith, £130.
insert new penultimate line to read Completed Qutb Minār 1828. *with ref. to new note to read* Bullock (11).
444 note 3, *after* Morier *for* 1853 *read* 1849, *and at end of note after* 1818, *insert JRGS.*, 1849 (xxxviii).

Page
448 to n.8 *add* ; *BM. Cat. MS.*, III (373).
451 n.5, line 2, *after* 463 *inside bracket insert* 74.
456 col. 2, *under* Williams, *line 4, after* com. *add* and in church of Ayot St. Lawrence, Herts, England. *and at end of line 12, after* daus., *add*; their ygst. son, Alfred, Ens. Bo. Inf., was kd. at Ft. Kahun. Sind, 31–8–40, aged 19; MI. Ayot St. Lawrence.
462 *against* Clarke, *line 1, for* Sir *read* Col.
470 col. 2, *against* Marine, *line 4, after* 191, *insert* ; 324 n.2, *and at end of line 5 del.* 335 n.2.
474 *against* Roxburgh *before* 384 *insert* Burkill, I (855) and after 384 add 405.
against Russell after *DIB.*; insert *Indian Archives.* VIII (59–66).

To following footnotes add page refs. to *IO. Cat.*

14 n.3	197	47 n.8	202	140 n.10	357
16 n.3	196	n.10	269	167 n.11	357
21 n.7	111	49 n.8	268	168 n.2	84
26 n.9	210	51 n.5	265	173 n.8	485
n.10	227	52 n.3	268	175 n.4	487
27 n.9	210	53 n.5	273–4	n.6	485, 487
34 n.2	226	55 n.16	259, 265	187 n.9	424, 428
n.8	114–5	57 n.7	258–9	277 n.7	319–20
40 n.5	469	58 n.5	160	385 n.7	482
43 n.4	468	68 n.2	113	392 n.15	210
44 n.4	201	90 n.9	235, 255	397 n.10	173
				457 n.3	445

To following Engr. Officers insert refs. to Conolly.

376	Arthur	98/87	415	Lawtie	86/94
382	Blakiston	98/95	416	Lindesay	86/96
384	Bradley	97/86	419	Macdougall	85/79
385	Cheape	86/99		Mackenzie	97/60
	Cliffe	103/21	428	Macleod	104/53
391	Colvin, CB.	86/100	429	Moncrieff	104/26
392	Cowper	104/29	430	Monteith	98/98
393	Dardell	104/31	432	Morrieson	85/91
	Dashwood	104/56	433	Nisbett	86/104
	Davidson	86/105		Nutt	104/41
	Davies	98/100	436	Paton	86/107
	De Havilland	97/77		Peckett	86/93
395	Dickinson	104/38	438	Price	104/47
396	Drummond	104/37		Ravenshaw	97/85
	Ennis	104/55		Remon	104/46
227	Fleming	84/39	439	Robertson, J.	85/68
399	Garrard	98/88		T.	84/52
	Garstin, E.	86/106	442	Smyth	87/139
400	Garstin, J.	84/35	443	Solomon	104/39
403	Goodfellow	104/35		Steel	85/76
	Gordon	104/34	443	Stephen	86/95
404	Hawkins	104/40	445	Tate	104/54
408	Hutchinson	86/103	446	Tickell	85/85
409	Hyde	85/84	457	Wilton	86/102
	Jervis, Geo.	104/51		Wood	85/80
	Johnson	103/23			

Addenda & Corrigenda Vol. III

Supplementary to lists on p. xvii of Vol. III and pp. vi and xiv of Vol. IV.

Page
vi *against* 403, *under* Grindlay *for* 16 m. map *read* map of India.
xix below *Briggs insert* Burke. Burke's *Peerage*, London. annual; all refs. to 101st edn. 1956.
xx below Fawcett *insert* Ferguson *Kashmir*; *An Historical Introduction.* J. P. Ferguson. London, 1961.
below Grigg *insert* Harleian Soc. *The Publications of the Harleian Society* occasional. London.
xxi col. 1, *below* Laurie *insert Listener*; periodical; British Broadcasting Corporation. London.
col. 2, *below* Puissant *insert Punjab Inscr. Inscriptions on Christian Tombs. ... Punjab.* 2 parts. G. W. de Rhé-Philipe. Lahore, 1919.
14 to n.3 add; *IO Cat.* (108), levels by Schalch, Prinsep, and others.
to n.4, *IO Cat.* (191); Prinsep's Map of Suburbs.
17 at end of line 10, *after* Haines *add*; On Coromandel Coast, 1821, William Maxfield [II, 429] Deputy Marine Surveyor General, surveyed Pulicat and Armagaon shoals, and Underwood of Madras Engineers surveyed the coast near Pulicat Lake [II, 429; III, pls. 1, 24], *with ref. to note reading MRO.* (6/38–9).
n.8, at end of *insert IO Cat.* (182).
25 n.3, *before* MRIO. *insert IO Cat.* (211).;
27 para 4 from bottom, line 6, *after* Garden *insert new note to read* ; *IO Cat.* (220).
32 n.2 *before* Ens. *insert*; Burke (888).

ADDENDA & CORRIGENDA, VOL. III

Page
37 to n.5, *add* ; cf. Section of the Mountain Provinces, Hodgson & Herbert, 1822, *IO Cat.* (92).
39 n.11, *before* [pl. 5] *insert*; *IO Cat.* (207–8), 4 m. map & Hodgson's astr. obsns. & fdbks.
40 n.6 *after* B 654; *insert* Supt. Bot. Gdns. Sahāranpur, 1817–23.
43 para 6 from bottom, line 2, *for* 1821 *read* 1820.
46 n.1, *for* ib. *read* BSO.
48 to n.5, *add* ; *IO Cat.* (223), fdbks. & barometer obsns.
49 to n.5, *add* ; fdbk., *IO Cat.* (302).
50 to n.2, *add* ; Memoir & 4-m. map, *IO Cat.* (302);
52 to n.3, *add* ; Maps of Cāchār by Fisher, Jenkins, Pemberton, MS., 1831–3; *IO Cat.* (299).
53 n.5, *after* Maps, *for* ib. *read*, 1825, *IO Cat.* (30); MRIO.
55 n. 6, *after IO Cat.* (118), *insert* Bedford's maps, 1824–6, tr. from IO to India, 1924 [324].
63 to n.7, *add*; *IO Cat.* (118), notebk. & fdbk.
64 para 6, *after* maps *add ref. to new note* to read *IO. Cat* (119); fdbks. & maps, Brahmaputra R.
to n.6, *add*; 16-m. maps by Wilcox, 1828, *IO Cat.* (298).
66 to n.7, *add* ; *IO Cat.* (167), routes into Burma, lithc. by Tassin, 1837.
70 to n.7, *add* ; *IO Cat.* (120), sketch of Irrawaddy, 1825–6, Lt. Geo. Winsor, RN. comdg. *Diana*,
73 to n.7, *add* ; Grant's map of Pegu, *IO Cat.* (306).
74 n.5, *for* (2, 3) *read* (2–4), *IO Cat.* (308);
to n.14, add; *IO.* (308–10), Martaban map, 1827, tr. to India, 1924 [324].
77 n.10, *for* 309 *read* 308–9;
80 n.10, *for* ib. *read* MRIO.
84 to n.8, *add*; 8-m. & 16-m. reductions adjusted to GTS., 1845, *IO Cat.* (264).
88 line 10 from bottom, *for* The *read* Ferguson's.
89 line 6, inside bracket, *before* II *insert* I: 30,
93 n. 2, *after* scales *insert* MRIO., at end of n.5 *add*; compns. ib. (271).
97 to n. 7 *add*; Memoir & 4-m. map Kudugu, or Coorg, *IO Cat.* (295), tr. to India, 1924 [324].
99 line 10, *for* II (438), *read* [II, 438].
101 to n. 2, as amended IV (vi), *add* ; *IO Cat.* (340), Masulipatam, 1816-7.
106 to b.4, *add* ; *IO Cat.* (414), memoir & 8-m. map, tr. to India, 1924 [324].
113 line 10, *for* Kundan *read* Kundah.
at end of para 5, after *Nilgiri District* insert ref to new note *to read* ; Memoirs, *IO Cat.* (325, 361) tr. to India 1924 [324].
n.1, *before* MRIO. *insert* ; S. Coimbatore, *IO Cat.* (325), map & memoir.
114 para 3, from bottom, line 4, *for* twenty *read* nine, *and after* years *insert* | 44
115 to n.9, *add* ; 4-m. map Moodgul & Raichur, 1817–8, *IO Cat.* (286).
117 to n.3, *add* ; 16 m. re n. ; SGO. Madras, ib., 23–0–19.
118 to n.6, *add* ; 4-m. map, 1813–4, *IO Cat.* (285); memoir & 8-m. map, ib. (291).
119 to n.3, *add* ; 4-m. map, 1817–8, *IO. Cat.* (285).
121 to n. 3, *add* ; *IO Cat.* (621), descriptive cat.
122 to n 7, *add* ; *IO Cat.* (416), 4-m. map, nr. Damān, Williams, 1817.
123 to n.6, *add* ; Symes' Journal, *IO Cat.* (140).
126 n.3, *after* 127 (9), *insert* ; *IO Cat.* (457).
to n.4, *add* ; *IO Cat.* (442), 8-m. map SMO., Deccan svy., Poona, 1827.
to n.7, *add* ; *IO Cat.* (441), base-line 2 measd. by Jervis, 1824; survd. by Dowell.
127 line 6, *after* Waugh *insert comma.*
131 n.3, *after IO Cat. insert* (454),
152 to n.8, as amended IV (vi), *add* ; Gorackpur city & cants., *IO Cat.* (217).

Page
153 para 6, line 1, *after* Sahaswān *insert* [154 n.5].
167 at end of line 9 from bottom, *after* interruptions, *insert* [II, 186–7].
to n.1, *add* ; 1-inch svy. N. Arcot, McMahon Howard, Allan, *IO Cat.* (371).
177 para 7, line 3, *for* 44 *read* 45.
205 at end of n.6, *add* ; *IO Cat.* (223), Webb's barometer obsns., ms.
208 para 4 from bottom, *for* 119 *read* 109.
222 at end of last line add ref. to new note, to read *JRGS.*, 1849 (xc).
275 to n.8, *add* ; *BM Cat. Pr.* 52450 (23).
276 line 2, para 2 from bottom, *before* political agent *for* the *read* Major William Murray *and after* Ambāla *insert* 1827–31.
to n.3, *add* ; *IO Cat.* (621) descriptive cat., Hodgson, 1827–9.
278 to n.5, *add* ; Nizām's Dominions, 16-m. map, 1826, *IO Cat.* (282).
279 to n. 2, *add* ; Arrowsmith's 4-m. Atlas, South India, 18 sheets, 1822; *BM Cat. Pr.*, Maps 146 c.6.
281 at end of para 4, from bottom, *after* inch, *insert ref. to new note* to read *IO Cat.* (416);
line 4 from bottom, *after* II, *insert* 282–5.
282 to n.9, *add* ; plans illustrating the Memoir, *BM Cat. Pr.*, Maps 12. c.10.
289 para 6, line 2, *after* inch *insert* ref. to new note to read *BM Cat. Pr.* 52450 (24).
note 5, *before* John *insert IO Cat.* (88), *and del.* G. & S. Cary. *after* 1820 *insert* ; pub. New Map of Hindoostan, 1806, *BM Cat. Pr.*, 52415 (6).
297 para 4, line 1, *read* Mountford.
314 para 4, line 3, *before* McReady *read* G. K.
370 line 8 from bottom, *against* BELL, col. 5, *before* unm. *enter* son of Geo. Banks Bell, Ben. Inf.
372 *against* SAXTON, *col. 5, as amended* IV (vi), *after* Sgt.-Maj. Saxton *insert* who m. 1801.
372 *against* WYATT, Geo. *col. 4, after* planter *add* Peera Estate, Champāran; *col. 5 for* Alexander *read* Alex. (*sup*).
385 *against* HILL, *col. 4, insert* after 1833 emp. on svy. of "Madras Jurisdiction".
against HOWELL, col. 5, give ref. to new note *to read* DDn. 544 (492), Howell to SG. 24–4–51.
422 col. 2, *under* BECHER, *line 6, after first* m. *insert* 4–9–35, *line 7, after* Art. *add* [IV, 416].
425 col. 1, *against* BLAKE, *line 1, enter* Ben. Inf.
426 col. 1, *under* BOILEAU, Alexander, *line 16, before* Colesworthy *insert* ; IV (638 ss).
col. 2, line 2, *under* John BOILEAU, *del.* II (623).
under BOYD, *line 5 from bottom, after* Kalāt, insert, *IO Cat.* 484.
427 n.5, *for* DDn. 221 *read* ib., *and at end of note add* ; *IO Cat.* (305), Browne's Journal, 1826.
433 col. 1, *under* COLVIN, *line 13, after* [24], *add* ; *IO Cat.* (235).
col. 2, *under* CRAWFURD, *at beginning of line 3, insert* arrd. India, 1803.
434 col. 1, *under* CRAWFURD, line 6, *after* FRGS., *insert* 1830, *and after* 1866 ; Athenaeum Club.
line 8, *RGS. Progs.*, to be in italics; at end of line add *JRGS.* 38, 1868 (cxlviii).
436 col. 1, *under* DAVIDSON, *line 3, for* 1861 *read* 31–12–61.
440 col. 1, *under* DRUMMOND, at end of line 7, *add*; *Punjab Inscr.* (93–4).
441 col. 1, line 2 from bottom, *under* EVEREST, *after* 145 *insert* ; IV (638 BB).
447 col. 1, *under* Feilding, *line 7 from bottom, before* svy. *insert* ; *IO Cat.* (264).
448 col. 1, *under* FORBES, *last line, for* Gregory his wife *read* his wife, dau. of Dr. John Gregory.

Addenda & Corrigenda, Vol. III

Page

450 col. 1, *insert as new line 10*—A John Gale, bach, m., 12-3-1816, Mary Tester. *with ref. to new note* to read *Harleian Soc.*, xxii, 1896.

451 col. 1, *under* Gerard, *line 11, del.* 35, 37.
col. 2, last line of para 5 from bottom, *after* [41], *add* ; *IO Cat.* (255).

452 col. 1, at end of line 15, *add* Name given to *pinus gerardii* of Kanāwar.
col. 2, *at end of line 7 from bottom*, *after* travel *insert ref. to new note to read* Constructed map of Kashmir [276].

457 to n.4, *add* ; *IO Cat.* (223), journal Aug.–Nov. 1818.

459 col. 1, line 2, *for* 370 *read* 369.
under Hodgson, line 7, *read* Harriott, *with ref. to new note to read* Their dau., Frances Anne, m. Wm. Delafield Arnold, 1828–59 Ben. Inf., nb., dir., bro. of Matthew Arnold, poet.
line 12, after 59–61, *insert* 232 *inside bracket, and after bracket* ; *IO Cat.* (208), fdbks. 1813–8,

461 to n.4, *add* ; *IO Cat.* (207); astr. obsns. and obsns. to snow peaks, from *JASB.* xiv.

462 col. 2, *under* Irvine, line 10, *after* (528–9), *insert* ; iv (638 vv).

465 col. 2, line 12, *after* S of I. *insert ref. to new note to read* reproduced as frpce *GTS.*, xvii.

484 to n.5, *add* ; *IO Cat.* (100, 108–9, 111, 197).

485 col. 2, *under* Moorcroft, line 2, *for* 1786 *read* 1770 *with ref. to new note to read* dnb. gives 1765 ?, but 1770 given by *Ency Brit.*, or even later, more probable in view of age on appt. to India.
line 11, add *Geo Mag.*, Aug. 1859 (204–14); *Listener*, lxiii, 1611 (260), 11-2-1960.
para 5, from bottom, line 4, *del.* an *and after* account *insert* tr. by h. h. Wilson and
n.9, *before* cf. *insert JRGS.*, 28, 1858 (clxxxiv).

489 col. 1, *under* Nelson, line 2, *after* uncov. *insert* b., England. c. 1790, *and after* 39, unm. & intest. *insert new line 4 to read* Son of Alex. Nelson ; *line 11 after* 575, *add inside bracket*, 638 jj.

490 col. 2, *under* Norris, *at end of line 6, add* ; Burkill, ii (55). iii (684).

491 col. 2, *under* Olliver, line 2, *add* d., Barrackpore, 1–11–53.
line 7, *after* another son *insert* was Henry ; *after* Edwin *insert* Olliver ; line 8, *del.* all.

493 col. 1, *under* Ommanney, *at end of line 9 add* 1845–6 laid down new bdy., Nepal–Purnea,

494 note 7, before *JRGS.*, insert *Memoir on Map of NE. Frontier.*

495 to n.2, *add* ; litho. *IO Cat.* (217).

496 col. 1, ine 2, *after* [448] *add* ; *IO Cat.* (111–2).
under Rees, line 2, *add* d. Berne, 5–1–62.

499 col. 1, *under* Ross, at end of line 14 from bottom, add *DIB.*; *at end of para 4 from bottom, after* 1809 *enter ref. to new note*; presented to rs. 1962.
col. 2, under Rossenrode, line 9, *after* 2nd *insert* DDn. 14–3–43, *and after* Eliza *insert* dau. of Lt.-Col. Hughes *and after* survived him *insert* and m., Meeri., 21–12–53, h. c. Williams.

500 col. 1, *against* Sandys, *read* Frederick.

503 col. 1, *under* Simmonds, *line 5, read* Catherine.

506 to n.2, add ; *IO Cat.* (223). Tate's fdbk., Dec. 1819 to Dec. 1821.

507 col. 2, at end of line 1, *under* Tetley, *after* 1800–5 *enter ref. to new note to read IO Cat.* (210).
under Thomson, para 2 from bottom, line 3, *after* 63 (5), *insert*, *IO Cat.* (167).
under Trant, line 2, *read* b. 1801/2. d., Gt. Biddoe, Ireland, 13–3–32. *insert two new paras* :—
Ens. hm. 38th Ft. 30–9–19 ; Lieut. (9–2–23), 95th Ft., 1–12–23 ; Capt. (27–4–27), 1st. wi. Regt. 1–11–27 ; 28th Ft., 29–10–29 ; with regt. in Dublin, taking leave early 1832.
Only son of Sir Nicholas Trant, of Old Bond St., London, who had served in Flanders, 1793, and with Portuguese militia during Peninsula War.

508 col. 1, *under* Trebeck, at end of line 5, add *Geo. Mag.*, Aug. 1859 (204–14).
line 24, *after* Ladākh, *insert ref. to new note to read* Sketch of Leh, *Listener*, lxiii, 1611 (260).
col. 2, *under* Turnbull, *at end of para 2, from bottom, after* 320–1, *add ref. to new note to read* ; Tinnevelly memoir left unfinished at death, *IO Cat.* (395–6).
under Van Heythuysen, *line 10, add* Hodson, iv (638 bb).

509 col. 1, under Voysey, line 5, *read* xiii, 1844 (853–62) ; xix, 1850 (192–212, 269–302), Diaries.

515 col. 1, at end of line 3 from bottom of Wilcox, insert ref. to new note to read *Ben. Sel.*, 23.
under Williams, *line 3, after* mi. *enter* local cem. and also in church. Ayot St. Lawrence, Herts. England.

516 col. 1, *against* Wotherspoon, *for* William *read* John *after* line 7 *add* Conolly 198/101).

520 col. 1, *against* Chambal *del.* 11, 51.

522 col. 1, *against* Dollond, line 3, *after* 1852 *insert* xiii (110).

523 col. 2, *against* Fulcher, *after* Hodson ii, *insert* (232); iii (781).

524 *against* Govan *before* 40 insert *JRC As Soc.*, Jan. 1962 (47–57); *for* 40 *read* 40 n.6.

525 *above* Howell *insert* Howard, Robt. (d. 1861/2) sub asst. Madras, 167 n.1, (*as amended above*), 385.
against Jacquemont, *after* naturalist *insert* Ferguson. (179–83) ; Burkill, i (877).

531 col. 2, *against* Saxton *add* 360 n.1, 372.

533 col. 1, *against* Tetley, *before* 1820 *insert* unm. *and for* 14 *read* 507.

534 col. 1, *above* Uniform *insert* Underwood, John James (d. 15–3–64). Mad. Engrs., 1816–45, Conolly 17, (*as amended above*).
against Wallich *after DNB. insert* Burkill, i (867, 872).

To following footnotes add page ref. to *IO Cat.*

11 n.1	178	72 n.9	355	98 n.6	459
13 n.7	121	77 n.16	513	99 n.2	354
17 n.9	181	78 n.4	207, 322	101 n.6	341
19 n.13	468	80 n.7	512–3	102 n.6	320
20 n.1	468–9	n.9	513	n.9	413
n.8	217	87 n.2	260–1	104 n.5	326
21 n.3	227–8	n.4	265	114 n.6	358
24 n.10	210–1	88 n.5	266, 268	123 n.9	140
26 n.1	214	n.12	276	131 n.4	137
52 n.5	302	89 n.4	265–6	132 n.2	239
63 n.11	311	91 n.6	279	152 n.3	217–8
65 n.5	300	n.8	26, 55	154 n.7	221–2
n.11	512–3	92 n.6	270–1	156 n.7	241–2
66 n.2	303	93 n.2	27	171 n.5	445
71 n.7	305	96 n.7	340–1		

To following Engr. Officers insert ref. to Conolly.

426	Boileau	87/135	464	Johnson	103/23
432	Buxton	86/109		Jopp	104/52
	Cheape	86/99	474	Mackenzie	97/60
433	Colvin, cb.	86/106	483	Macleod	104/53
435	Crommelin	86/123	484	Mallock	87/133
436	Davies	98/100	492	Ommanney	88/155
437	De Butts	86/115	495	Prinsep, t.	86/120
439	Dickinson	104/38	496	Ravenshaw	97/85
448	Fitzgerald	86/117	496	Remon	104/46
	Forbes	86/108	502	Sim	98/103
	Foster	105/66	503	Slight	104/59
451	Garstin, e.	86/106		Smith	85/56
454	Gilmore	87/152	506	Tate	104/54
456	Hall	86/98		Taylor	85/90
	Hemming	104/61	507	Thomson	86/118
462	Irvine	86/110	516	Wotherspoon	98/109
463	Jervis, t.	104/58			

Addenda & Corrigenda Vol. IV

Supplementary to list on p. xiv, Vol. IV.

Page
v Addenda Vol. II, col. 1, *against* p. 23, line 3, *after* Blunt, *add* ; *IO Cat.* (181).
vi 372, *against* Saxton, line 2, *after* who *insert* m., 1801 and
xi *under* Chapter XII, last line, *for* Coast *read* Cost.
under Chap. XIII *line* 1, *read* North.
xii *under* Chapter XIX, *line* 3, *read* Allahābād.
xiv *under* Plates, *line* 1, *read* Political.
xvi col. 2, against Burkill, *for* Journ. *read* Journal; line 3. *read* vols. 51 to 63, 1953–63.
below Fanshawe *insert* Ferguson. *Kashmir—A Historical Introduction*. J. P. Ferguson. London, 1961.
xvii against *P R.*, read (*Parliamentary*).
xviii against *Punjab Inscr.* line 2, *read* Rhé-Philipe.
30 line 9 from bottom *read* [106].
35 line 8 from bottom *read* [32–34].
45 chapter heading, for *Rods* read *Bars*.
90 at end of para 4, *after* 352 *inside bracket insert* ; IV, t-page.
98 at beginning of para 6, *for* He *read* Everest.
101 at end of para 6, *inside bracket before* 17, *insert* t-page.
112 line 4, from bottom, for II *read* III.
115 para 7, line 3, *after* 1830 *insert ref. to new note* to read, *IO Cat.* (424–5), obsns. by Glanville-Taylor; cat. of stars, 1844.
117 note 8, after Grisenthwaite *insert* who m., Simla, 27–4–43, Frances Charlotte Crawley.
118 to n.6, add ; *IO Cat.* (630), pub. obsns. 1872, and Tables, 1850.
141 line 11, from bottom, *after* series *del., rest of line, and read.* No. 2 was used on the Great Arc till
154 *para* As a general, *beginning of line 5, for* of *read* on.
168 line 3 from bottom, *after* "Hills" *insert ref. to new note to read* GBO. Lib. D (7), map of tea plantations Kumaun & Garhwal.
180 at end of para 3, *after* mouzahwar *insert* [206].
187 to n.6, *add* ; ½-inch map of Orissa from svys. 1837–42, *IO Cat.* (180–2).
191 to n. 6, add ; *IO Cat.* (175–6); Midnapore Dist., 1838–45.
192 para 2 from bottom, line 1, *for* 1845 *read* 1847.
196 to n.5, add ; *IO Cat.* (177), Chittagong Rev. svy., 1835–41.
198 *under section* Tippera, *line 3, for* 1836 *read* 1838.
200 to n. 4, *add* ; Thuillier's, 1-inch map of Cāchār, *IO Cat.* (299), Jaintia, ib. (301).
204 to n.7, add ; Burkill, II (57); Tassin's 4-m. map, 1839, showing tea-tracts discovered by Bruce, *IO Cat.* (298).
214 to n.3, add ; *IO Cat.* (206–7), 4-m. maps.
215 line 11, *after* 1839 *insert* [221–3] *with ref. to new note* to read *IO Cat.* (213–4, 218).
222 n.5, *after* (45–6), *line 6, insert* ; *IO Cat.* (213).
227 n.3, line 4, *for* (iii) *read* (214–6, 222–3).
228 line 10, from bottom, *for* 289 *read* 299.
240 n.2, line 2, *for* 84 *read* 184–212.
242 at end of para 9, *after* [269–70] *add ref. to new note* to read *IO Cat.* (276).
243 to n.5, add ; *IO Cat.* (231), Burnes' Map of Territory of the Sikhs, 1831; n.6, *for* ib. *read Bokhara*.
245 to n.6, add ; *IO Cat.* (484), svy. Quetta to Kalat, 1842.
246 against map 5, *after* Le Messurier *insert*; *IO Cat.* (138); map 9, ib. (235, 470); map 11, ib. (259).
247 line 14, *read* Peninsula;
at end of para 5 from bottom, *after* Mosul *enter ref. to new note*, Ormsby's svys., *IO Cat.* (491).
note 1, *read* Lt.-Col. F. J. Goldsmid, Supt. Indo-Eur. Telegraph from 1865.
to n.3, *add* ; Haines' svys. *IO Cat.* (488, 500, 590, 597).

Page
250 n.4, line 3, *before* 400 *inside bracket, insert*, 357.
253 line 2 from bottom, *after* explored *insert ref. to new note to read* Goomsur svy., 1836–7, 2-m. sketches with Hills' report, *IO Cat.* (326–7).
to n.5, *add* ; country about Purla Kimedi, *MRO.* (12/93).
255 n.4, *for* (363–371) *read* (363–4); N. Arcot, Macpherson, 1837–8; ib. (371).
256 n.4, *after* (1–107) *insert* ; maps by Du Vernet, Macpherson, Morland; *IO Cat.* (285–90).
261 to n.4, *add* ; marine svys. of Indian coast suspended 1861–73.
264 line 9 from bottom, *after* Bankok *insert* ref. to *new note*, to read *IO Cat.* (308), 16-m. map, Tenasserim, W. C. McLeod; ib. (304), 32-m. map of British Burma, 1870.
265 to n. 10, *add* ; Memoirs on NE. frontier, 1825–46, Wilcox, Pemberton, Griffiths, Bayfield, Jenkins, Veitch, Brodie, *IO Cat.* (299).
269 at end of line 8, insert ref. to new note, to read *IO Cat.* (276), Midnapore to Nāgpur, Haines.
at end of line 12, insert ref. to new note, *IO Cat.* (167–8), Bengal, routes, Garden, W. 1838.
line 12 from bottom, *after* reduction *insert* of 1848–50.
270 to n.1, add; *IO Cat.* (211–2), showingr oad bridges; *BM Cat. Pr.* Maps 2. b. 38, Agra–Bombay road, 4-m. to inch; sqo., 1851.
271 line 5, *for* the trunk *read* Ranken's trunk.
line 6, *after* Mundunpoor *insert* [1: 38, 368].
at end of para 6, *after* [288] *enter ref. to new note* to read *JASB.*, IX, 1840 (889).
272 to n.10, *add* ; 12-m. map, *IO Cat.* (259).
273 n.2, line 2, *after* 84 (31–2) *insert IO. Cat.* (231).
274 section heading, *after* Exploration *enter ref. to new note to read* See early map of Hazarajat, S. of Oxus GBO. Lib., F (3).
to n.1, *add*; personal account of Ranjīt Singh, Ferguson (44–7).
278 to n.2, add; *IO Cat.* (475–7), route to Hindu Kush; to n. 5, *IO Cat.* (474–5).
281 at end of line 5, insert ref. to new note, to read *IO Cat.* (237), map by John Walker, 1841, NWP. 20 m. to inch; ib. (255–6), 14-m. map, 1842.
282 to n.1, add; *IO Cat.* (234), Durand's fdbk.
n. 3, *before* Plan *insert IO Cat.* (453).
to n.10, add ; *IO Cat.* (235, 478), routes by Anderson, Durand, Sturt, Broadfoot, Peat.
287 to n.4, add; *IO Cat.* (208), 16-m. Dist. Index Map NWP., 1851.
289 n.7, line 6, *after* 165–6, *inside bracket, insert* 207.
290 line 9 from bottom, *before* John Henderson *insert* In 1835. *del.* a Bengal *and after* surgeon *insert* to the Agent to Governor-General at Ludhiāna.
line 6 from bottom, *before* He died *insert* He met Vigne and von Hugel in Srinagar [472].
after He died *insert* of cholera.
lines 1 and 2 from bottom *for* this particular agent *read* Abdul Rahim.
to n.3, *add* ; Ferguson (185–90).
292 to n.11, *add*; GBO. Lib., map E/5.
306 at end of para 2 from bottom, *after* map *add* [III, 281].
349 *against* Berrill, col. 2, *enter* b. 1799–1800.
col. 5, *enter* 1853, Hotel-keeper, Masri., son of Wm. B.; m., 17–10–53, Matilda, dau. of Isaac Christan.
350 *against* Geo. Stapleton, col. 5, *after* Eleanor *add* who d., Calcutta, 8–1–62, aged 49.
369 *under* Anderson, Geo. col. 1, *after* Sligo *del. stop.*
against Day; col. 2, *for* 1872/7 *read* 7–5–75.

ADDENDA & CORRIGENDA, VOL. IV

Page

369 *against* STATHER, *col. 5, add* ret. as Lt.-Col. 1856.

376 line 17 from bottom, *for* original estimate of *read* authorized.

line 16 from bottom *del.* had *and* were needed *and after* casualties *insert* Everest had asked for.

379 lines 5 and 6 from bottom, *after* 1838 *read* He held charge of the Computing Office at Calcutta till his death on 30th March 1845.

381 note 2, Thos. Hill ; *after* till 60 *insert* ; emp. after 1833 on svy. of "Madras Jurisdiction" ; survd., 1837–9, Madras & Suburbs., 26¼ sq. m., 6-inch scale, pub. 1842 ; *IO Cat.* (354). *and after* 14–10–33, *add* ; ib 405 (251), 7–10–43.

384 *against* LANE, col. 2, *enter* d., Calcutta, 7–11–83. col. 5 *add* m., Benares, 2–10–48, Jemima Elizabeth, dau. of Thos. Milner.

385 *against* TORRICK, Andrew *at end of col. 4, add* clerk, Hdbd. Resdcy. 1863.

386 *against* BUCKALL, col. 2, *enter* d., 1–1–68 ; MI. Wanauri, Poona. col. 4, *after* 1833 *add* later hd. dmn. QMG.'s Dept.

397 *against* BRADLEY, col. 2, *enter* b. 1805/6 ; arrd. India 1813/4 ; d. 27–9–60.

against BURKE, *end of col. 3, insert ref. to new note.* Survd. Singrauli caves, 1848, *IO Cat.* (270).

399 *against* HUDSON, C. E., *col. 4, add* with lime merchs. Cherrapunji, 1862.

400 above OTTO *insert* OLLIVER Chas. Adolphus. b. 1825/6. appd. 1841. Rev. Svy. LP., 1841–2 ; WT. SGO. 1843/4 ; GTS. from 20–1–44, till resd. 1852 ; yst. son of Joseph O. [III, 491].

against PRINGLE John, Col. 1, *for* 1819–20 *read* 1812/3 ; col. 3, *add* ret. 1867/8, aged 55.

against THORNTON, col. 3, *add* ; EAG. Golaghāt, 1863.

402 line 12 from bottom *read* conference.

416 col. 2, *under* James ABBOTT, *line 8, before* 1826, *insert* arrd. India 1823 ; *line 9, before* 1832, *insert* 1830–35, regtl. duty at Mhow.

to n. 1, *add* ; profuse writer ; auth. of *Tales of the Forest*, pub. London, 1853.

417 col. 2, *under* ANDERSON, *at end of line 7, after* 366, add *IO Cat.* (235), fdbk.

under ARROWSMITH, *to line 6* add *JRGS*, XLIII (CXLV). *at beginning of last line insert* FRGS., 1830 ; *shift* 1863 *to end of line and del.* RGS.

under BAKER, at end of line 9, *add* Conolly (87/143) ; line 10, *after* canals *insert* ; *IO Cat.* (114).

above last line *insert new line to read* ; 1846, 1st Sikh War, battle of Sobraon, 10–2–46, *IO Cat.* (336).

419 under BATTEN, line 5, *add* his dau., Katherine Jane, m., 1856, John Strachey (1823-1907), BCS.

420 under BEDFORD, line 10, *for* James *read* Alex.

421 col. 1, *under* BOILEAU, *line 5 from bottom, for* 30 *read* 29/30.

424 col. 2, para 8, line 5, after Murray *insert to ref. new note to read* Capt. Wm. Murray (1791-1831), Ben. Inf., PA. Ambāla 1827 till death, Sabāthu, 28–6–31 ; collected material for Gerard's map of Kashmir [III, 276].

427 col. 2, *under* CARLESS, *insert new line 5, IO Cat.* (186), chart of Indus, Hdbd. to sea, 1836.

note 8, *after* xli *inside bracket add*, -xlvii.

428 col. 2, line 1, *under* COURT, *after* 5000 *del.* The Itinerary...and pub. *and read* A translation was pub. *JASB.*, XIII (827–53). and ;

under CREED, *line 3 from bottom, before* 453, *inside bracket, insert* 259, *and after* 453 *insert* 458.

under CUNNINGHAM, line 13, *after* Condon *insert* ; *IO Cat.* (77–8), Archl. Reports, 1862–5.

below line 19, *above* 1846–7, *insert new line to read* ; 2nd Sikh War, survd. battle area, Chiliānwala, 13–1–49 ; *IO Cat.* (237).

429 col. 1, under DAVIDSON, line 3, *read* 1848–50.

Page

430 col. 1, *under* DEL'HOSTE, *line 3 from bottom, after* (22 *et seq*) add ; *IO Cat.* (447–9), *and add new last line to read* 1850, DQMG., Bombay.

under DE PENNING, line 6, *delete* ret. Nov. 1843.

431 col. 2, *under* DURAND, *bottom line, after* Pass *enter ref. to new note* to read, *IO Cat.* (480), Bolan Pass.

432 col. 2, para 5, line 4 *inside bracket, insert*, 71 *after* 64.

433 col. 2, line 9, *omit* eld ; lines 15–6, *for* founder member 1830 *read* 1845.

at end of note 5, *add* ; Alfred, 2nd. son (1856–1928) lived at the Orchard, Letchworth, Herts, and d., unm., 1930/5. Everest's dau. Ethel, d. 1916, founded at Hever, nr. Edenbridge, Kent, the "Everest Home of Rest", still maintained 1960. Infn. from Brig. John Sheffield, late RA., gt. g. son of Thos. Wing, father-in-law of Geo Everest.

435 col. 1, line 7, *read* Kidarkanta.

440 note 5, *to read* Capt. James Murray (1824–1904), Ben. Inf., ; inv. 1855 ; d., DDn., 10–2–1904, MI.

441 col. 2, para 5, line 3, *for* men *read* man.

442 col. 1 line 12, *after* photographer *insert* frpce. GTS., XVII.

443 col. 1, *under* FITZPATRICK, line 12, from bottom, *after* pm. *insert* from 1–1–41.

col. 2, *under* GAISFORD, line 3, *for* 1852 *read* 18–11–54.

445 col. 1, at end of last line of GIBERNE *add* ; amateur botanist, Burkill, III (685).

note 5, *for* 1–535 *read* 1–5–35 ; note 6, *for* 303–5 *read* 303–4 *and after bracket add* ; III (785).

446 col. 1, *under* GRIFFITH, *line 13, after* Burkill *insert* II.

447 note 4, *add* cf. eulogy by survrs. of 2nd Afghān War, *GR. 1880–1*, p. 35, para 163.

448 col. 1, *under* HUTTON, at end of line 9 *add* she d., Mssri. 25–5–86, aged 73 ;

insert new line 10, Hodson, II (516) ; III (802).

col. 2, *at end of line 8*, add ; *John Jacob of Jacobabad* ; H. T. Lambrick. London, 1960.

at end of line 7 from bottom, enter ref. to new note, *IO Cat.* (625), obsns. by Taylor & Jacob, printed Madras, 1854.

449 col. 1, under JENKINS, line 7, *for* 542–50 *read* 549–50 *add at end of line* ; III (805) ; Burkill, II (37–9).

451 col. 1, line 4, *after* Bokhara *enter ref. to new note* to read *IO Cat.* (473), Meyendorff's map of Bokhara, litho, by Jervis, 1843.

col. 2, at end of last line *under* JONES add *IO Cat.* (115).

n.5, *for* 514 *read* 63/239, 514, *and after* sheets ; *IO Cat.* (534–5), scale about 2¾ m. to inch, in 2 parts.

452 under KITTOE, line 5, *before* Eliza *insert* Harriet.

line 9, *after* (603–4), *insert*, III (810).

454 col. 2, under LEECH, at end of line 7, *insert ref. to new note* GBO. Lib. C (3) ; ½-inch map by Leech, March 1838.

above A devoted student *enter new para to read*, *IO Cat.* (136) describes Indus fords and bridge of boats at Attock.

under LLOYD, *line 4, for* 49 *read* 40.

456 col. 2, last line *under* MARGARY, *shift* Oct. 1839, *to beginning of line, followed by* as Ex. Engr., *and after* Sukkur *add* ; *IO Cat.* (449).

457 under MATHISON, *insert* new line 10 *to read* Hodson, III (256) ; IV (635–BB).

459 col. 1 under NELSON, line 4, *add* unm. & intest. line 10, *add, inside bracket*, 638 JJ.

col. 2, *under* NORTH, *line 6, after* Herat *enter ref. to new note*, to read, *IO Cat.* (480).

460 under OUTRAM, line 5, *for* and *read DNB* ; line 6, *before* Margaret *insert* m., Byculla, Bombay, 18–12–35 ; *after* Margaret *del.* his wife *and after* Anderson *insert* LLD. ; *line 7 after* Aberdeen *del.* and

Addenda & Corrigenda, Vol. IV

Page
line 7 from bottom, *after* Mahi Kantha *insert* [240].
n.3, *del.* pr.
462 under Rees, line 2, *add* d. Berne, 5-1-62.
under Renny-Tailyour, line 4, *for* 1795 *read* 1776.
col. 2, lines 4–5, for refs. *read* [114–5, 339–41, 375, 379–81].
463 col. 1, under Renny-Tailyour, lines 9 and 10 from bottom, *for* at end of the rains *read* Dec. 1843,
lines 7 & 8 from bottom, *del.* inspected...before being
line 3 from bottom, *del.* for 2 mo. taking *and read* in March 1844, after inspecting Shortrede's Karara ser. as reported to DSG., 22-2-44 [466 n.7]; took
col. 2, under Rind, line 8 from bottom *after* estate, *insert ref. to new note to read* MRIO. 15 (11–3), traverse along Pioneer Road past Bhadrāj *deota* [III, pl. 5, reverse].
464 col. 1, under Rivers, line 3, *read* 2/Lt., 11-6-39.
465 col. 1, *under* Shakespear, *line 4 from bottom, after* Khiva, *insert ref. to new note IO Cat.* (473), route Khiva to Dusht Kulla.
against Sherwill, line 1, *add* Ben. Inf.
466 col. 2, *under* Shortrede, *para 5 from bottom, after* by you *enter ref. to new note to read.* Report on Ganges canal, *IO Cat.* (113).
468 col. 2, *under* Stephen, *at end of last line, after* longs. *add* ; *IO Cat.* (89).
under Sturt, *at end of para 3 from bottom add* ; Eur. Letters, I, (83 a) II (10).
add to note 4 ; *v. A Peep into Turkistan*, by Rollo Burslem, London 1846, pp. 10, 11.
469 to n.5, add ; *IO Cat.* (169); also maps of Inland Nvgn. and of rivers, Calcutta to Himalaya, 1835 ; *IO Cat.* (100).
to n.7, add ; *IO Cat.* (624–5), obsns. Madras Obsy.
471 col. 2, line 6, *under* Thuillier, *for* 1878 *read* 1877, *and at end of line del.* 366.
472 col. 1, *under* Fraser-Tytler, *line 4 from bottom, for* 480 *read* 480–1 ; *line 2 from bottom, add ref. to new note* ; map, battle of Maharājpur, 29–12–43, *IO Cat.* (267) ; routes in Baluchistān, ib. (483).
col. 2, under Vigne, line 2, *read* d. 12/3–7–63.
at end of para 5 from bottom, *after* great blank *add* Met Baron von Hugel who left Kashmir with him.
474 col. 1, under Western, line 12, *add* Conolly (88/168).
475 col. 2, *under* Wood, *for* Sind *read* London.
line 6, read *JRGS.* XLII. line 6–7,
for 20, 21n., *inside bracket, read* 20 n.4 21 n.1.
476 col. 1, *last 3 lines under* Wood, *del.* Fatigue consequent upon ; *for* a *read* A ; *to last line add* He only survived his return to England by 14 days ; *JRGS.* 42 (clvii).
col. 2, *at end of para.* On his return, *after* 214–5 *insert* 222 *inside bracket.*
at end of note 2 *add* GBO. Lib. C (4), ½-inch map Cabul & Turkestan, 1838.
477 col. 2, *against* Anderson, *line 1, for* 639 *read* 369.
against Arabia *add* Arab seamen, 247.
against Armstrong, *at end of line 1, read* 65–6.

Page
478 col. 1, *insert* Barnes, Geo. (b. 1799), clerk, 349.
col. 2, *against* Bedford, *for* A. not James *read* Alex. *and del.* XIV, XVIII.
480 *against* Chamarett, line 2, for 386 *read* 385 twice.
482 *against* Elliot, *at end of line 2, for* :—*read* fullstop.
line 3, *before* Surg. *enter* Elliott.
against Falconer, *after* DIB. *add* ; *JRGS.*, 35 (XVI *et seq*) ; Burkill, IV (342).
483 *for* Goddine *read* Gooddine *and shift below* Gomonde.
against Grisenthwaite, *after* Beaufoy *insert* alias G. J. Percy.
484 *against* Hodgson, line 2, *shift* 398 *to follow* 392 *at end of line* Hodges.
485 *against* Kashmir, *after* Map *insert* 290,
after Kelly, *insert* Wm. Michael.
against Lane, for b.1817 in in bracket read 1817–83.
486 *against* LeMessurier, *for* 433 *read* 245-6.
against Ludlow, *after* Edgar *insert* Owen *and for* d. 1888 *read* 1812-88, *and after* Engrs. *insert* Conolly (100/157).
against McClelland, *after* geolgt. *insert* Burkill, II (58, 67–9), V(788).
shift Matak R. *above* Mathematical.
against Map, line 8, *for* Exn. *read* Exmn.
487 *against* Murray, *for* Capt. *read* James (1834-1904), *and after* Inf. *del.* (?) 424 *at end of line add* :—Wm. (1791-1831), Ben. Inf., 424.
488 col. 1, *against* Olliver, *line 3, for* b. 1785/6 *read* 1785/6–1853.
against Pemberton, *line 2, after* 114 *insert* 263–5, 295.
490 *against* Royle, *last line, add* Burkill, I (871–2), III (693).
against Sabine, *line 2, before* 105 *insert RS. Progs.*, LI. 1892 (xliii).
against Salaries, *line 4*, Madras Topo., *del.* 402.
against Saugor, *line 2, shift* & Narbada *to follow* 271, *and insert to follow* 270 n.2.
492 *for* Sussed *read* Sussex.
493 *against* Tweedale, *before* Ben. Cav. *insert* d. 12-12-83, MI. DDn. cem.
against Wade, at end of line 1, *after DIB.* ; *insert* FRGS., 1846.
against Wellsted insert Markham (16 ns. 1, 2).
col. 2, *against* Whewell *after* FRS. *insert* FRGS., 1837.
against Wolff, *after DIB.* ; *insert* Ferguson (184–6) ;

To these footnotes add references to *IO. Cat.*

183 n.3	180–1	241 n.2	439	273 n.5	247
204 n.2	302	244 n.6	447	275 n.5	474 n.5
222 n.7	212	247 n.4	500	282 n.3	453
223 n.1	212	252 n.7	372	n.11	481
224 n.6	216	263 n.3	171	288 n.5	206–7
226 n.4	214–5	267 n.7	105	295 n.2	472
228 n.1	216–7	n.5	106	305 n.5	85–8
n.5	218	269 n.2	168	417 n.1	472
n.8	277	271 n.4	274–5	448 n.3	453

Addenda & Corrigenda, Vol. V

Plate 9, reverse. Designation "Capt. in ch. No. 4 Topographical Party Chota Nagpore Division" not applicable before 1861.

Page
21 note 2 *for* 455 (12–30), 9–12–50 *read* 569 (153–60), 10–6–53.
34 note 2 *for* I (12–4) ; *read* I, sects. ii, iii, vi, vii ; III ; IV.

Page
35 note 3 *for* treaty *read* proclamation.
81 para 4, line 2, *read* Kidarkānta ; *line 3, before* IV, 38, *inside bracket, insert* III, pl. 5 ;
83 line 11 from bottom, *read* Chomothāri.
92 line 5 from bottom, *read* professional.
93 last word of para 5, *read* peak.
98 line 19 from bottom *read* they should...be observed

PREFACE

This fifth volume brings our story of the Indian surveys to the retirement of Andrew Waugh in March 1861, one hundred years after Hugh Cameron had been appointed to survey the Company's new lands in the Calcutta *parganas*.

In 1761 the map of India was strangely mis-shapen and largely blank. Little was known beyond the coastline and its main ports, and the position of many a celebrated city was sadly out of place. The courses of the great rivers and mountain ranges were utterly distorted. Though there was some knowledge of the peoples and their rulers nothing whatever was known of the limits of their territories.

As British influence extended inland from the great Presidency towns, Calcutta, Madras, and Bombay, knowledge of the country became more important, especially for the movement of troops. The wisdom of Robert Clive led to the appointment of James Rennell in 1767 as Surveyor General of Bengal for genuine geographical purposes, whilst the struggles against the Marāthas in the west, and Haidar Ali and Tipu Sultān in the south, led to the explorations of Charles Reynolds and his appointment as Surveyor General of Bombay, and to the more orderly surveys of Colin Mackenzie in Mysore.

In 1800, with the backing of Arthur Wellesley, William Lambton started his trigonometrical survey under the orders of the Madras Government, and by 1815 he had spread a network of triangles over the south peninsula with a central chain from Cape Comorin to Hyderābād.

In 1815, the Court of Directors in London appointed Colin Mackenzie to be their first Surveyor General of India, and they followed this in 1818 by appointing Lambton to be Superintendent of the Great Trigonometrical Survey of India, both taking orders direct from the Supreme Government in Calcutta.

On Lambton's death in 1823 he was succeeded by his assistant George Everest, who now came under the orders of the Surveyor General, Valentine Blacker, whose firm advocacy led to the acceptance of the trigonometrical survey as sole foundation for all surveys and maps. Everest brought the great central arc north to latitude 24°, but his health then broke down and he had to take long leave to England. For seven years he had been working through the most unhealthy jungles with only occasional respite. Like Lambton, however, he had given his whole heart to the work, and spent the years 1825 to 1830 making contact with the leading geodesists and instrument-makers of Europe and gaining the trust of the Directors.

He wrote a detailed account of the work of the Great Trigonometrical Survey between 1818 and 1825, describing in particular the professional details of the Great Arc between latitudes 18° and 24°. He deduced values for the figure of the Earth from his preliminary computations, and discussed the best means to ensure the very highest precision for future operations.

He returned to India in 1830 with the combined offices of Surveyor General and Superintendent of the Great Trigonometrical Survey, and armed with orders to give first priority to the extension of the Great Arc to the Himālaya. Revenue surveys were to proceed at the discretion of local Governments, but geographical and topographical surveys depending on astronomical observations were "expressly prohibited". The quarter-inch Atlas of India—authorized in 1824—was to be compiled in London by the Company's Geographer John Walker from material based on, or properly connected to, the trigonometrical survey. To ensure that these orders would be carried out satisfactorily full responsibility was entrusted to Everest alone, and in order "to preserve a system of perfect uniformity" the Directors abolished the branch survey offices at Madras and Bombay.

Authority was given to raise six field parties for work on the Great Arc and subordinate triangles in Bengal, and for Everest to take over the party already working in Bombay. The four topographical parties working in Madras and the Nizam's territories of Hyderābād continued one-inch survey based on Lambton's triangles.

For the new triangulation parties Everest had only three military officers who had been employed on geographical surveys in Assam and Bengal, and four of his old civil assistants, so he had first to recruit and train a number of others. He had to work out detailed procedure for field observations and computations to suit his new instruments and local conditions. He was determined that the results should stand up to criticism from Europe, and with this intent he himself took charge of work on the Great Arc to meet all difficulties and to lead and check the work of his beginners. He set an extremely high standard and had many disappointments amongst his staff; some failed from lack of ability or temperament whilst others broke down in health.

He worked himself to a shred; when he was not himself handling the instruments, he was harassed with details of administration and of correspondence, not only with his own staff but also with Government Departments, local officials, and the topographical parties. During 1835 he was seriously ill with malignant malaria, but he took the field in October as usual, taking Andrew Waugh in charge of a second party.

Before setting out to the field in 1832 he had organized computing and drawing offices to work at Calcutta. From 1838 these were placed under James Bedford who had been brought down from the North Western Provinces for charge of the revenue surveys of the Lower Provinces, and now became the Surveyor General's personal Deputy at Calcutta.

By 1843, with the assistance of Waugh and Renny, Everest had completed all field observations and computations of the Great Arc northwards to Dehra Dūn, latitude 34° 20′, and this included the re-observation with the new instruments and under the new system, of all the old work; between Bīdar and Sironj special astronomical observations had been, made for calculation of the figure of the Earth.

His general plan for the triangulation provided for a grid based on the Great Arc, with major longitudinal chains connected by subordinate series running north and south. By 1843 his parties had completed three of the subordinate series and commenced on three others, and on the northern longitudinal chain breaking eastward from the head of the Great Arc. The southern longitudinal chain along parallel 24° had been carried out by his assistants during his absence in England.

At the end of 1843 he handed over to Waugh seven triangulation parties well trained to a sound practical system, though somewhat short of experienced observers.

The only topographical work remaining was that of the Nizām's Territories which still had a long programme ahead of it. The district revenue surveys of the North Western Provinces of Bengal had been completed to the satisfaction of the local Government, but several of those of Assam and the lower provinces had to be closed down prematurely for reasons of economy. None had been connected to the trigonometrical survey. From 1837 the Bombay Government had put in hand a system of village field surveys which fully met the needs of their revenue officers but were useless for topographical or geographical purposes.

The seventeen years of Waugh's administration form the subject of this volume. Triangulation was advanced eastward to cover the Ganges valley to Calcutta, and extended up the Assam valley till switched south across the Khāsi Hills, whilst another series ran down the east coast to cross the Godāvari. After the Sikh wars of 1846–8 two major longitudinal chains were taken across Rājputāna and along the Punjab foothills to close on the Great Indus series that stretched 750 miles from Karāchi to Attock. Except for a few subordinate series Waugh saw the completion of the principal triangulation north of parallel 24°. As triangulation advanced topographical survey was taken up in Orissa, the Punjab, and in the western Himālaya from the Ganges to the Indus.

By insistence on regular observation to the Himālayan peaks Waugh was responsible for the discovery of the highest mountain in the world, 29,002 feet above the sea, which he recommended should be named after George Everest who had built up the triangulation system by which the discovery was alone made possible. He gave much thought to the problems of refraction and deflection of gravity, and his clear statements on their complexities contributed largely to later study. He appreciated the need for greater accuracy in the determination of height, and initiated the system of precise levelling, connected to sea-level by means of tidal observations.

On his departure from India in March 1861, he handed over the office of Surveyor General to Henry Thuillier who as his Deputy had held charge of the revenue surveys of the Bengal Presidency and of the headquarter offices at Calcutta for fourteen years. As Thuillier had no geodetic experience the Great Trigonometrical Survey was taken over by James Walker under whom it made vast strides in many directions during the next twenty-two years.

Under Thuillier's administration the Department was re-organized into three distinct branches, each with its own cadre under a Deputy Surveyor General. Rates of pay and terms of service were revised on a more generous scale such as Waugh had long urged. The number of topographical parties was increased, but surveys were still organized for specified districts or states. From 1869 the compilation and printing of the Atlas of India was transferred from London to Calcutta.

From 1871 Bengal revenue surveys took the form of cadastral surveys on the large scale of 16 inches to the mile. The revenue surveys of Madras and Bombay, however, never came under control of the Surveyor General.

Thuillier retired from 1st January 1878, when Walker assumed the office of Surveyor General in addition to that of Superintendent Trigonometrical Surveys, and the three branches were henceforward closely amalgamated under the new designation Survey of India. The Department continued to flourish and extend during the next twenty-five years, making special progress in geodetic operations such as the determination of longitude by telegraph.

Topographical and geographical surveys were extended in all directions, but except in the processes of map reproduction and the introduction of the clinometer, the systems of survey and mapping failed to keep pace with the latest scientific advances or the needs of the engineering and other professions. To rectify these shortcomings a Survey Committee was formed in 1905 which made sweeping recommendations that were put in hand with lasting benefit. These included :—

Re-organization of the cadre, scales of pay, and terms of service right through the Department.

Organization by administrative circles.

Introduction of an orderly lay-out for maps and surveys, with a key that provided a simple relationship between maps of the various scales that were definitely specified. This involved the abandonment of the old $\frac{1}{4}$-inch Atlas of India.

The ancient value for the longitude of Madras as determined by John Warren in 1807 (see volume II, p. 195), which had till now been retained for all mapping purposes, was abandoned, and the latest value adopted.

The introduction of an order of priority for surveys and mapping to meet the more pressing needs. Surveys were in future to be carried out to geographical limits as defined by parallels and meridians instead of by administrative boundaries.

From 1905 work proceeded smoothly on these lines, with occasional changes to meet new demands.

It would be of great interest if this series could be carried to at least as far as 1905. Annual reports are too disjointed to give a continuous narrative ; they carry no general index, and seldom give reasons for changes or any critical review. These would be helpful to Government Department and professional surveyors who may wish to follow the steps by which the work has developed, and learn the why's and wherefore's of past and present practices. An authoritative narrative is

desirable to describe technical details and official discussions and decisions, problems faced, and difficulties overcome. However firmly rules may be laid down in textbooks and standing orders they carry far more weight when background is given in an interesting narrative.

A work of this sort cannot be read straight through as if it were a detective story ; different readers will find different passages of interest, and it is hoped that where interest is aroused opportunity may be found to follow up the reference to published or manuscript sources. The heavy lists of addenda and corrigenda should not be overlooked. Paste-up bundles of original material, chapter by chapter, have been deposited with the National Archives in New Delhi ; those for biographical notes of British personnel, being largely collected in England, have been deposited with the Society of Genealogists in London.

It may be thought that overmuch space has been devoted to these personal details and the nominal rolls, but they undoubtedly add to the interest of some readers, and were not despised by Sir Clements Markham. All students of Indian geography should if possible read his classic *Memoir on the Indian Surveys* as well as the earlier treasures, Rennell's *Memoir of a Map of Hindoostan* and Everest's two Great Arc books.

In writing this fifth and final volume I have received help and encouragement from many friends, particularly Dr. de Graaff Hunter who has read through all the chapters on geodetic subjects, and was surprised at Waugh's grasp of the problems of refraction. Professor Mason's wide knowledge of the Himālaya Mountains has been placed freely at my disposal. He has constantly pressed for the fullest detail.

For the biographical notes I am indebted to the most generous help from the late Major Hodson which has gone far beyond the range of his *List of the Officers of the Bengal Army*. The late Sir Patrick Cadell, with unsurpassed knowledge of the Bombay Presidency, said it was my duty to carry on to complete an 8th volume. Mr. Burton has been tireless in unearthing facts and dates from the arcana of the India Office Records in London. I have been most fortunate in making contact with descendants of some of our surveyors who have helped with interesting details of survey life. Officers of the National Archives of India have given me freely of their specialized knowledge.

Above all, I have to thank the Surveyor General, the Director of Map Publication, for their encouragement and help and the members of their technical staff at Dehra Dūn for the able way in which they have carried through the printing both of letterpress and illustrations.

Volume I having been out of print for the past few years, authority has been obtained for the preparation of a revised edition that will embody all the new information collected during the last 17 years.

DEHRA DUN :
JANUARY 1964.

R. H. PHILLIMORE.

Plate 3

INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA
NORTH OF HYDERABAD

SHOWING THE MERIDIONAL AND LONGITUDINAL CHAINS OF PRINCIPAL TRIANGLES;
THE BASE LINES MEASURED WITH THE COLBY APPARATUS.
THE LINES OF THE SPIRIT-LEVELLING OPERATIONS,
THE ASTRONOMICAL & TIDAL STATIONS.
AND THE SECONDARY TRIANGULATION TO FIX THE PEAKS OF
THE HIMALAYAN & THE SOOLIMANI RANGES.
Completed to 1st May 1861

REFERENCES

The course of the Levelling operations is shown by a dotted line .....
The stations where the Latitude has been observed astronomically by a star ✱
The stations where an Azimuth has been observed astronomically, thus +
The Principal triangulation done before the year 1830 is shown by fine lines. after that year by thick lines.
No Secondary triangulation is shown excepting that to the peaks of the mountains on the northern frontier.

32°
28°
24°
20°

PESHAWUR
KASHMIR
LAHORE
Amritsar
Loodhiana
Ferozepoor
Umballa
PUTTIALA
Simla
Chamba
Gangotri
Kamet or Ibi Gamin 25,373
Raikee Kal
Manasarowar Lake
Nanda Debi 25,614
Panchu Chuli
Api
LASSA or H'lassa
Shigatse or Digurtchi
Dhaulagiri 26,826
Pundoong 23782
MOUNT EVEREST 29,002
Kunchinjinga 28,156
Pemberi
Choomalari 23,944
Darjeeling
Sona Khoda Base
Purneah
Kooch Behar
Dinajpoor
Nyncusing
Rungpoor
Moorshedabad
Berhampoor
DACCA
Comilla
Jessore
Calcutta Base
CALCUTTA
Backergunj
Chittagong
Mouths of the Ganges
Midnapoor
Choto Nagpore (Ranchi)
Sirgoja
Oodeypoor
Sambulpoor
Kesinjur
Balasore
Tidal Station
Cuttack
Mahanuddy R.
Karrasall
GANJAM
Pooree
Jeypoor
Vizagapatam Base
DELHI
Meerut
Agra
Muttra
Allygurk
Shahjehanpoor
Furruckabad
Myenpoorie
Etawah
Cawnpoor
LUCKNOW
Oudh
Goruckpoor
Azimgurh
Jounpoor
Benares
Mirzapoor
Allahabad
Rewah
Sironj Base
Saugor
Jubbulpoor
Seonee
Nerbudda River
Bhopal
Sehor
Augur
Sagur
Indore
Mhow
Amjerrah
Dhar
Oomrait
Seepor
Ellichpoor
NAGPOOR
Ramgurh
Ruttunpoor
Belaspoor
Rypoor
Kumpta
Bundara
Karinjah
Ramgurhat
Chanda
Dhoolia
Malligaum
Aurungabad
Jalna
Amba
Godavery R.
Nirmal
Elgundel
Medchul
Sattara
Poona
BOMBAY
Kaira
Ahmedabad
Mahee R.
Mhye R.
Nerbudda R.
Taptee R.
Rajbah
Goondul
Jetpoor
Morvi
Nuggur
Dwarka
Porbundar
Kattiawar Triangulation
Tidal Station
Diu
Pahlanpoor
Deesa
Oodeypoor
Nusseerabad
Jeypoor
Ajmer
Jodpoor
Bikaner
Jeisulmer
Sukkur
Sehwan
Nuggur Parkur
Mithan Kot
Bukkur
Sutlej River
Indus
Sutlej Series
Ourbagarh Meridional Series
Rahoon Meridional Series
Jeypoor Meridional Series
Lucknow Meridional Series
Oorai Meridional Series
Kamptee Meridional Series
Kaira Meridional Series
Aboo Series
Oodeypoor Series
Nusseerabad Series
Sironj Base
Calcutta Longitudinal Series
Sambulpoor Longitudinal Series
Kings Peramnath Series
Bombay Longitudinal Series
Coast Series
Eastern Frontier Series
Assam Longitudinal Series
Kurrachee Base
Tidal Station
HYDRABAD
Kurrachee
Longitudinal Series
GULF OF KUTCH
GULF OF CAMBAY
GREAT ARC SERIES
Godavery
Kistna R.
Kistna Series
Poona Longitudinal Series
Kaira Series
Nal D.
Kullianee
Sattara
Bidar Base
Bidar
Kullianee
Jeypoor
Vizagapatam Base
Coast Series
Eastern Frontier Series
Assam Longitudinal Series
Kings Peramnath Series
Sambulpoor Longitudinal Series
Calcutta Meridional Series
Rungpoor
Moorshedabad
Berhampoor
Jessore
Midnapoor
Choto Nagpore (Ranchi)
Sirgoja
Oodeypoor
Sambulpoor
Kesinjur
Balasore
Tidal Station
Cuttack
Mahanuddy R.
Karrasall
GANJAM
Pooree
Mouths of the Ganges
Backergunj
Chittagong
Comilla
Jessore
DACCA
Calcutta Base
CALCUTTA
Midnapoor
Choto Nagpore (Ranchi)
Sirgoja
Oodeypoor
Sambulpoor
Kesinjur
Balasore
Tidal Station
Cuttack
Mahanuddy R.
Karrasall
GANJAM
Pooree
Jeypoor
Vizagapatam Base
Coast Series
Eastern Frontier Series
Assam Longitudinal Series
Kings Peramnath Series
Calcutta Meridional Series
Rungpoor
Moorshedabad
Berhampoor
Jessore

CONTENTS

	Pages
Survey Maxims	t-page, reverse
Addenda & Corrigenda : Vol. II ... v Vol. IV	ix
Vol. III ... vi Vol. V	xi
Preface	xiii
Contents	xvii
References to MS. Records & Other Abbreviations	xxiii
Publications	xxiv

Chapter I

General Narrative

Notable Events					1
Great Trigonometrical Survey : North-East ...	1	North-West ...			2
Spirit-Levelling					3
Topographical Surveys					3
Revenue Surveys : Bengal, Lower Provinces					5
Upper & Central Provinces	6	Punjab ...			7
Bombay & Sind	7	Madras ...			8
Maps ... ... Conclusion					9

Chapter II

North-East Quadrilateral

Meridional Series : Karara, 1838–45					11
Gurwāni ... Gora					12
Hurilaong ... Chendwar ... North Maluncha					13
Calcutta ... 14 North Parasnāth					15
North-East Longitudinal, 1846–51					16
George Logan 17 Sonakhoda Base					19
Eastern Section 19 West Connection					21
Conclusion					21

Chapter III

East Coast & Assam

South Maluncha Series, 1845–7					22
Coast Series : Hill & Clarkson, 1847–52 ...					23
Peyton, 1852–5, 26 Strange & Basevi, 1856–61 ...					27
Assam Longitudinal : Du Vernet, 1853					29
Nicolson, 1853–6, 30 Lane, 1857–8					31
Eastern Frontier, 1859–61					31

Chapter IV

North-West Quadrilateral

North-West Himālaya Longitudinal : Du Vernet, 1847–50 ...					34
Logan, 1850–2					36
Great Longitudinal, 1848–53					37
Base-Lines : Chach, 1853–4 ... 42 Karāchi, 1854–5 ...					43
Great Indus Series, 1852–6 ... 44 ; 1856–60					47
Interior Series : Rahun, 1852–63 ... 49 Jogi-Tila, 1853–63 ...					51
Gurhagarh, 1847–52 ... 50 Sutlej 1860–3 ...					53

Chapter V

Bombay Triangulation
Bombay Party Meridional Series : Singhi, 1842–61 ... 54
Khānpisura & Aramlia, 1845–9 55
Abu, 1850–2 Kāthiāwār 1851–62 57
Cutch Coast, 1853–7 ... 59 Gujarāt Longitudinal, 1851–61 60

Chapter VI

Geodetic Heights
Vertical Angles ... ... 62 Refraction 63
Trigonometrical Heights ... 66 Spot Heights... ... 67
Tidal Observations : Bay of Bengal 69 West Coast 72
Spirit-Levelling 74

Chapter VII

Snow Peaks
Early Observations ... ... Nepāl & Sikkim, 1845–51 ... 81
Kumaun to Kashmir ... 86 K 2 : Discovery & Name ... 88
Computations 90
Mount Everest : Height 93 Identity & Name ... 94

Chapter VIII

Reconnaissance & Preparation
Instructions ... 97 Approximate Series ... 99
Lay-out 100 Ray-Traces 103
Towers : Bengal 105 East Coast 108 Indus Valley 109 Punjab 111
Platforms & Marks 112

Chapter IX

Observing & Computing
Final Angles 114
Changing Zero 115 Observatory Duties 116 Signals ... 117
Secondary & Minor Triangulation 118 Triangulation Charts ... 120
Computations : Forms & Formulæ 121
Auxiliary Tables 122 Geographical Positions 125
Logarithm Tables 123 Field Parties 126
Initial Elements 124 Records & Reports 127
Dispersal of Errors 128

Chapter X

Astronomical & Other Scientific Work
Astronomical Observations 130 Azimuths ... 131
Himālayan Attraction 133
Departmental Observatories 137
Meteorology 139 ... Photography 141
Electric Telegraph 140 ... Geology 142
The Schlagintweit Brothers 144

Chapter XI

Instruments
Theodolites 148
Three-foot 150 18-and 15-inch... ... 155
Two-foot 152 Small 156
Base-Line Equipment... 158 Levels & Staves ... 159
Perambulators 160
Care & Custody ... 162 Workshop & Depot. ... 163

Chapter XII

Topographical Surveys: Madras Establishments
Ganjam ; Goomsur, 1844–50 167
Orissa : Cuttack Tributary Mahāls, 1850–3 168
Tributary Mahāls & Sambalpur, 1853–7 170
Coast, 1857–8 173
Tributary Mahāls & Khōnd Hills 174
Hyderābād 1844–50 177 1855–66 ... 178
Nīlgiri Hills, 1844–52 179

Chapter XIII

Topographical Surveys: Bengal, Bombay, Burma
Calcutta ... ... 181 Central India & Gwalior 188
North-East Frontier ... 183 Rājputāna 190
Chota Nāgpur ... 184 Bombay 191
Upper Provinces & Oudh 184 Sind 192
Himālaya Mountains ... 185 Burma 194 Pegu ... 195

Chapter XIV

Topographical Surveys: Punjab & North-West
North-West Himālaya : Kangra, Kulu, & Spiti 200
Chamba 204 Sutlej to the Ganges ... 206
Punjab : Hazāra 208 Rāwalpindi & Jhelum ... 209
Peshāwar ... 214 Derajāt 217

Chapter XV

Kashmir, 1855-65
Preparation, 1849-55 ... 220 Baltistān & Ladākh, 1858–61 232
Pir Panjāl, 1855 ... 222 Trans-Himālaya, 1862–5 ... 236
Kashmir Valley, 1856 225 Maps & Memoirs ... 238
Kashmir & Jammu, 1857–8 226 Little Tibet 240

Chapter XVI

Revenue Surveys: Lower Provinces, Bengal
General Narrative 241
No. 1, or North Division, Purnea to Dinājpur 244
No. 2, or South Division : Midnapore, 1844–7 246
Hooghly 1844–6 247 Calcutta Suburbs, 1846–52 ... 249
24-Parganas, 1846–52 248 Nadia & Burdwān, 1852–60 ... 250
No. 3, or East Division, Sāran & Tirhut, 1843–9 251
Mymensingh & Dacca, 1850–60 253
No. 4, or West Division, Shāhābād to Bākarganj 254
Revision of Boundaries 256

Chapter XVII

Revenue Surveys : Upper India—Bombay—Madras

Upper India : Rohilkhand, 1848–54 258 NWP & Oudh ... 263
Delhi 264 Bundelkhand ... 267
Rājputāna 265 Central Provinces, 1846–51 ... 267
Punjab : Cis-Sutlej 268 Trans-Sutlej 270 Bari *doāb* ... 272
Rechna & Jech *doābs* 273 Sind Sāgar *doāb* ... 274
Bombay ... 275 Sind ... 276 Madras ... 279

Chapter XVIII

Professional Details : Topographical & Revenue Surveys

Topographical : General Instructions 281
Manual of Surveying ... 283 Traverse Survey ... 288
Revenue Surveyors ... 284 Planetable Survey ... 288
Triangulation ... 285 Computing & Mapping ... 290
Bengal Revenue Surveys ... 292 Connection with G.T.S. ... 295
Traverse Control ... 297 Units of Measure ... 302
Instruments ... 298 Field Tests 303
Demarcation of Boundaries 299 Faulty Work 303
Field Survey, or *khasrah* 300 Maps 305

Chapter XIX

Maps

General Maps of India ... 307 Punjab & NW. Frontier ... 316
Atlas of India ... 309 Himālayan Areas ... 318
Assam & NE. Frontier ... 311 South India 319
Bengal & Upper Provinces ... 312 Map Drawing 320
Central India & Rājputāna ... 315 Orthography 321
Custody & Distribution ... 322

Chapter XX

Map Reproduction

Outside Agencies 325
Departmental : Litho-Printing 327 Photo-Lithography ... 331
Postage Stamps 332

Chapter XXI

Administration : The Surveyor General

Surveyor General & Superintendent Trigonometrical Surveys ... 336
Field Office : Clerks 341 Draughtsmen 342 Computers ... 343
Correspondence & Reports ... 344 Finance ... 346

Chapter XXII

Deputy Surveyor General & Calcutta Offices

Deputy Surveyor General ... 348 Supt. Revenue Surveys ... 349
Calcutta Premises ... 351 Observatory 356
Correspondence Branch ... 352 Lithographic Press ... 357
Drawing Office, Calcutta ... 353 Mathematical Instruments 357
Computing Office ... 354
Nominal Rolls : Clerks Draughtsmen 359 Computers ... 360
Lithographic Press Mathematical Instrument Department ... 360

Chapter XXIII

Field Units

Field Parties : Trigonometrical 361
Topographical 363
Revenue ... 364
Field Season 365
Recess Quarters 368
Transport : 370
Boats & Elephants ... 372
Railways 374
Field Allowances ... 375
Guards & Escorts ... 376

Chapter XXIV

Military Surveyors

G.T.S. : Appointments 379
Promotion 381 Training 382
Topographical Surveys :
Madras & Burma ... 383
Hyderābād ... 384
Ganjam & Orissa ... 385
Punjab 387 Kashmir 388
Disputes & Censure : Shortrede 390
Rivers ... 391 Du Vernet 393
Saxton ... 395
Revenue Surveys : Benga 395
Bombay ... 398
Survey Allowances ... 398
Nominal Rolls : G.T.S. ... 399
Topo. Surveys ... 399
Revenue Surveys : Bengal 400
Bombay & Berār ... 400
Madras ... 401

Chapter XXV

Civil Assistants : Great Trigonometrical Survey

Appointments & Postings 402
Allowances ... 405
Work 409
Misconduct ... 412
Successful Careers ... 414
Nominal Roll ... 418

Chapter XXVI

Civil Assistants : Topographical Surveys

Madras & Hyderābād 421
Punjab & Himālaya ... 422
Burma 425
Successful Careers ... 426
Allowances ... 429
Nominal Roll ... 430

Chapter XXVII

Civil Assistants : Revenue Surveys

Appointments ... 433
Successful Careers ... 434
The Lesser Fry ... 436
Nominal Rolls : Bengal ... 439
Bombay & Berār ... 444
Madras ... 445

Chapter XXVIII

Indian Staff

Surveyors : G.T.S. 446
Topographical Parties 446
Early Explorers 447
A Bombay Experiment 449
Revenue Surveys, Bengal ... 450
Khalāsis & Lascars : G.T.S. ... 452
Topo. Parties ... 455
Revenue Surveys ... 455

Chapter XXIX

Sickness & Health

General 456
Assam 461
East Coast ... 462

Chapter XXX

The Country & its People
Natural Obstacles ... 467
Destruction of Markstones ... 469
Disputes & Complaints ... 470
Armed Assaults ... 473
Civil Aid : British Districts 476
Indian States ... 478
Mutiny of 1857 : General ... 482
Field Parties ... 483

Biographical Notes 487
Index 545

Plates

1. India, north of Hyderābād ; Political... ... Front Cover
2. Safed Koh, from Kurram Valley ... ... facing page iv
3. G.T.S. Chart, north of Hyderābād xvi
4. North-East Quadrilateral 32
5. North-West Quadrilateral... 33
6. Kashmir Triangulation, 1855–65 36
7. Cuttack Tributary Mahāls, Orissa 174
8. Hyderābād Survey, Berār 178
9. Indus River & Attock, Atlas Sheet 14 179
10. Upper Sutlej & Spiti River 204
11. North-East Chamba 206
12. On the Jhelum–Pindi border 214
13. Kashmir Route-Map & part of Kashmir Valley, 1860 ... 232
14. Srinagar City, Kashmir, 1859 238
15. Pir Panjāl panorama 240
16. District Map, Bengal Presidency, 1846–61 258
17. from Chittagong Revenue Survey 306
18. Bombay ; Atlas Sheet 25, 1854 310
19. Coorg ; Atlas Sheet 19, 1827 311
20. Indian Postage Stamps, 1854–5 336
21. Portraits, Waugh, Henry Thuillier, James Walker ... 337
22. ... Walker, Basevi, Strange, Tennant 488
23. ... Montgomerie, Godwin-Austen 489
24. ... Thuillier, Depree, John James, Robinson ... 500
25. ... Hennessey, Herschel, Pemberton, Branfill ... 501
26. ... Saxton, Depree 526
27. ... Radhanath Sickdhar 527
28. India, Progress of Survey, 1861 ... ... Back Cover

Further Abreviation

A/A G.	..	Assistant/Adjutant General
A D C.	..	Aide-de-Camp
A/D/Q M G.	..	Assistant/Deputy Quartermaster General
A G G.	..	Agent to Governor General
A R.	..	Astronomer Royal
A S B.	..	Asiatic Society of Bengal
A S G.	..	Assistant Surveyor General
Absent wl.	..	Absent without leave
Acc/d/y.	..	Accompan/ied/y
Acct.	..	Account
Accy.	..	Accuracy
Ack.	..	Acknowledge
Actg.	..	Acting
Addn/l.	..	Addition/al
Adm.	..	Admitted/Admiral
Admin.	..	Administra/tion/tive
Allce.	..	Allowance
Appce.	..	Apprentice
App/d/t/n.	..	App/oint/ed/ment/lication
Apprx.	..	Approximate
Appx.	..	Appendix
Arr/d/g/l	..	Arriv/ed/ing/al
Art.	..	Artillery/Article
Assmt.	..	Assessment
Asst/ce/d.	..	Assist/ant/ance/ed
Asste.	..	Associate
Astr.	..	Astronom/er/ical
Attd.	..	Attached
Auth.	..	Author
B/Bo/M/S C.	..	Bengal/Bombay/Madras Staff Corps
B to CD.	..	Bengal Letter to Court of Directors
B C S.	..	Bengal Civil Service
B G O.	..	Bengal General Order
B M C.	..	Bengal Military Consultations
B R C.	..	Bengal Revenue Consultations
b.	..	born
Bnkpy.	..	Bankruptcy
bapt.	..	baptized
Barr.	..	Barrister
Bart.	..	Baronet
Batt.	..	Battalion
Bd/of Admin.		Board / of Administration, Lahore, 1846–52
Bde.	..	Brigade
Bdgs.	..	Buildings
Bdy.	..	Boundary
Ben.	..	Bengal
Biog.	..	Biograph/ical/y
Bo/C S.	..	Bombay/Civil Service
Bo Geo Soc.	..	Bombay Geographical Society
Bot.	..	Botan/ical/ly
Br.	..	Branch/British
Br/Assn.	..	British/Association for the Promotion of Science
Bro.	..	Brother
Bt.	..	Brevet
Bur.	..	buried
C in C.	..	Commander-in-Chief
C B.	..	Companion of the Bath
CD.	..	Chief Draughtsman/Court of Directors
C D/to/B/Bo/M.		Court of Directors/Letters to Bengal/Bombay/Madras
C E.	..	Chief Engineer
C I.	..	Central India
C/I E/S I	..	Companion of the/Indian Empire/Star of India
C L.	..	Circular Letter
C M G.	..	Companion of St. Michael & St. George
C P.	..	Central Provinces
C R E.	..	Commanding Royal Engineer
C R O.	..	Commonwealth Relations Office, London
c.	..	Approximately
Cadl.	..	Cadastral
Camb.	..	Cambridge
Cants	..	Cantonments
Cape G H.	..	Cape of Good Hope
Capt.	..	Captain
Cartr.	..	Cartographer
Cav.	..	Cavalry
Cem.	..	Cemetery
cf.	..	compare
Ch.	..	Chapter/Church/Chief
Ch/Comnr.	..	Chief/Commissioner
Chpn.	..	Chaplain
Circs.	..	Circumstances
Civ/Audr.	..	Civil/Auditor
cl.	..	Class/Clerk
do.	..	company/county
Col.	..	Colonel/Column
Coll/n/r.	..	Coll/ege/ection/ector
Comn/d/r	..	Commission/ed/er
Comd/d/g/r/t	..	Command/ed/ing/er/ant
Comm/t/y.	..	Comm/ittee/issar/iatly
Comp/g/n/r/s	..	Comput/ation/ing/er/ations
Condr.	..	Conductor
Conn/g.	..	Connect/ing/ion
Confmd.	..	Confirmed
Cons Engr.	..	Consulting Engineer
Constn.	..	Construction
Cont.	..	Contingent
Corn.	..	Cornet
Corr.	..	Correspondence
Cous.	..	Cousin
D/A/A/G/Q M G.		Deputy/Assistant/Adjutant/Quartermaster/General
D/ACG.	..	Deputy / Assistant Commissary General
DC.	..	Deputy Commissioner
D D.	..	Doctor of Divinity
D G O S.	..	Director General, Ordnance Survey
D I G.	..	Deputy Inspector General
D/L.	..	Deputy Lieutenant
DDn.	..	Dehra Dūn/Survey Correspondence now with NAI.
D L R.	..	Director of Land Records, West Bengal; rev. svy. records now with NAI.
D O.	..	Departmental Order/Drawing Office.
D S G.	..	Deputy Surveyor General
d.	..	died
dau.	..	daughter
Dep.	..	Deputy
Dept/l.	..	Department/al
Dett.	..	Detachment
diff.	..	difference
Dir.	..	Director
Disch.	..	discharged
Dism.	..	dismissed
Dist.	..	District
Div.	..	Division
Dmn.	..	Draughtsman
Drg mr.	..	Drawing Master
Dro.	..	drowned
d s p.	..	died without issue
E.	..	East
E I C.	..	East India Company
E I U S	..	East India United Service
Eccl.	..	Ecclesiastical
ed/cn.	..	editor/educat/ed/tion
edn.	..	edition
eg.	..	for example
eld.	..	eld/er/est
emp/t.	..	employ/ed/ment
Engv/d/r	..	Engrav/ed/er
Eng/r/g.	..	Engineer/ing
Ens.	..	Ensign
Est.	..	Establishment
et seq.	..	and the following
Eur/Letters	..	Europe/an/Regiment/Letters to Gen. Walker, STS., 1864–72; GBO Lib. Q. 68.
Ex/Engr/Off.	..	Executive/Engineer/Officer
Expn.	..	Expedition
Extn.	..	Extension
F D.	..	Foreign Department
F/G/L/S.	..	Fellow of/Geological/Linnean/Society
F M.	..	Field Marshal
F R/A/G/S	..	Fellow of Royal/Astronomical/Geographical/Society
F R C S.	..	Fellow of the Royal College of Surgeons
F R I B A.	..	Fellow of the Royal Institute of British Architects
F S A.	..	Fellow of the Society of Arts
Fact.	..	Factory
Fd.	..	Field
Fig.	..	Figure
Fin/Dept.	..	Financ/e/ial/Department
frpce.	..	frontispiece
Ft/St/Geo/Wm.		Fort/Food/Saint/George/William
fur.	..	furlong
Furl.	..	furlough
G of I.	..	Government of India
GBO/Comp/Lib.		Geodetic Branch/Computing Office/Library, Dehra Dūn
GG/in C.	..	Governor General/in Council
G O.	..	General Order
G S I.	..	Geological Survey of India
G T road	..	Grand Trunk road
G T S.	..	Great Trigonometrical Survey
Gdns.	..	Gardens
Gen.	..	General
Geogl.	..	Geographical
Geol/gt.	..	Geolog/ical/ist/y
Gov/r/t	..	Govern/or/ment
Gr Sch.	..	Grammer School
gr.	..	grade
g.son	..	grandson
Gt Arc.	..	Great Arc
H A.	..	Head/Accountant/Assistant
H C.	..	Honorable Company
H D.	..	Head Draughtsman
H E.	..	His Excellency
H E I C.	..	Honourable East India Compnay
H H.	..	His Highness
H M.	..	Her/His/Majesty
H M S.	..	Home Miscellaneous Series, IO/CRO.
H S.	..	Hill Station, G.T.S.
h p l.	..	half-pay list
Hdbd.	..	Hyderabad
Hdmr.	..	Head Master
Hdqr.	..	Headquarter
Helio-z.	..	Helio-zincography
Hldrs.	..	Highlanders
ho.	..	house
Hon.	..	Honor/able/ary
Hosp.	..	Hospital
ht.	..	height
IA.	..	Indian Army
I C S.	..	Indian Civil Service
I G.	..	Inspector General
I O/Records	..	India Office/Records, now with CRO.
I S C.	..	Indian Staff Corps.
I W.	..	Isle of Wight, Great Britain
ib.	..	the same
incl.	..	including
Inf.	..	Infantry
inf.	..	below
Infmn.	..	Information
Inspr.	..	Inspector
Inst.	..	Instrument
Instn.	..	Inst/itution/ruction
Intpr.	..	Interpreter
Intro.	..	Introduction
Inv.	..	Invalid/ed
Irrgn.	..	Irrigation
J. P.	..	Justice of the Peace
Jud.	..	Judicial
junr.	..	junior
K & J Hills	..	Khāsi & Jaintia Hills
K C/B/MG/SI.		Knight Commander of the Bath/St. Michael & St. George/Star of India
kd.	..	killed
Kt. Bach.	..	Knight Bachelor
L/C/I.	..	Light/Cavalry/Infantry
L G.	..	Lieutenant-Governor
L L D.	..	Doctor of Laws
L P.	..	Lower Provinces, Bengal
Lat.	..	Latitude
Lib/rn.	..	Librar/y/ian
Lieut.	..	Lieutenant
Litho/d/r.	..	Lithography/ed/er
Long/l.	..	Longitud/e/inal
Lt.	..	Lieutenant/Light
Lt Col.	..	Lieutenant Colonel
M A G.	..	Military Accountant General
M C S.	..	Madras Civil Service
M D.	..	Doctor of Medicine
M Gen.	..	Major General
M I.	..	Monumental Inscription
M I C E.	..	Member of Institute of Civil Engineers
M I/M/O/D.	..	Mathematical Instrument/Maker/Office/Dept.
M N I.	..	Madras Native Infantry
M O.	..	Medical Officer/Madras Observatory
M R I O.	..	Map Record & Issue Office, Survey of India; early maps now with NAI.
M S.	..	Manuscript
m.	..	married/miles
Mad.	..	Madras

FURTHER ABREVIATION—*Concld.*

Math/l/n/s.	..	Mathematic/al/ian/s
Maj.	..	Major
Matric.	..	Matriculation
mc.	..	medical certificate
max.	..	maximum
Mdpn.	..	Midshipman
Meas/d/t.	..	Measure/d/ment
Med.	..	Medical
Memo.	..	Memorandum
Merch.	..	Merchant
Merdl.	..	Meridional
Metl.	..	Meteorological
Mgte.	..	Magistrate
Mil/Bd.	..	Military/Board
min.	..	minute of correspondence
Misc.	..	Miscellaneous
Missny.	..	Missionary
mo.	..	month
Nasri.	..	Mussoorie
Mtn.	..	Mountain
N A I.	..	National Archives of India, New Delhi.
N/E/W.	..	North/East/West
N I.	..	Native Infantry
NW/F/P.	..	North-West/Frontier/Province
N/Y/Z.	..	New/York/Zealand
n.	..	footnote
nat.	..	natural (out of wedlock)
neph.	..	nephew
no.	..	number
Notfn.	..	Notification
nr.	..	near
Nvgn.	..	Navigation
O S.	..	Ordnance Survey of Great Britain
o s.	..	old series
Obj/t.	..	obituary
Obs/d/g/n/r/y.	..	Observ/ed/ing/ation/er/atory
Off/d/g/r.	..	Offic/iated/ing/er
Opns.	..	operations
Ordn.	..	Ordnance
Orgl.	..	Original
P A.	..	Personal Assistant/Political Agent
P & M Rolls.		Pay & Muster Rolls, War Office, P.R.O.
P R O.	..	Public Record Office, Chancery Lane, London
P M G.	..	Postmaster General
PR/GS/S.	..	President, Royal/Geographical/Society
P S.	..	Private Secretary/Postscript
P W D.	..	Public Works Department
P W I.	..	Prince of Wales Island (Penang).
P Z O.	..	Photo-Zinco. Office, Dehra Dün.
para.	..	paragraph
passim	..	here and there
Photo-Zinco	..	Photo-zincography
p/p.	..	page/s
Permt.	..	Permanent
Phys.	..	Physician
pl.	..	plate
pr.	..	probably
Prcpl.	..	Principal
Pref.	..	Preface
Presd/t/cy	..	Presiden/t/cy
Prof.	..	Profess/ional/or
Progs.	..	Proceedings
Prov.	..	Province
Pt.	..	Planetable/Point
pr.	..	probably
Pub/n.	..	Publi/shed/cation
pymr.	..	paymaster
Q M G.	..	Quartermaster General
Qmr.	..	Quartermaster
Qn.	..	Qualification
Qrs.	..	Quarters
R A.	..	Royal/Academy/Artillery
R & A. Dept.	..	Revenue & Agriculture Department, G of I.
R C.	..	Roman Catholic
R/E/N.	..	Royal/Engineers/Navy
R M/A/C.	..	Royal Military/Academy/College
R S.	..	Royal Society
Recd/d/g/n	..	Rec/eived/ommend/ed/ing/ation
Recce.	..	Reconnaissance
ref.	..	reference
Regr.	..	Register
Regt/l/r.	..	Regi/ment/al/istrar
repn.	..	reproduction
res/d/n.	..	res/ign/ation/ed/olution
Ret/t.	..	Retire/d/ment
Resd/t/cy.	..	Resident//cy
Rev.	..	Revenue/Reverend/Review
Rev Bd./LP/WP		Revenue Board/Lower/Western Provinces
Rlwy.	..	Railway
S A.	..	South Africa
S A S.	..	Sub-Assistant Surveyor
S & M.	..	Sappers & Miners
S C.	..	Staff Corps
S E.	..	Superintending Engineer
S/E/W.	..	South/East/West
SG/O/Fd Corr.		Surveyor General of India/Office, at Calcutta/Field Correspondence series, now at N.A.I.
S of I.	..	Survey of India
S M C.	..	South Mahratta Country
S M E.	..	School of Military Engineering, Chatham
S O.	..	Settlement Officer
S S I.	..	Secretary of State for India, London
S T S.	..	Superintendent of Trigonometrical Surveys
Sch/mr.	..	School/master
sd.	..	signed
Sec/tt.	..	Secretar/y/iat
senr.	..	senior
Settmt.	..	Settlement
Sgt.	..	Sergeant
sh.	..	shilling
sic.	..	thus, as printed
sis.	..	sister
Soc.	..	Society
sq.	..	square
Stokes' Sch Regr.		Regr. of Stokes' Sch. Mussoorie, MS. with Soc. Geneologists, London
Stn.	..	Survey station of observation
Subdn.	..	Sub-division
Subs.	..	Substantive
Succ/g.	..	Succeed/ing
(*sup*)	..	above
Sup/dg/t	..	Superintend/ent/ed/ing
Surv/d/g/r.	..	Survey/ed/ing/or
Surg.	..	Surgeon
sv.	..	under the heading
Svy.	..	Survey
T S.	..	MS. Professional Report/Tower Station/GTS.
Tel.	..	Telegraph
Tempy.	..	Temporary
Terr.	..	Territories
Topo.	..	Topographical
t-page	..	title-page
tr.	..	transfer/ed/lated
Trav.	..	Traverse/d
Trg/tgn/gtr.	..	Triangulat/ing/ion/or
Trib.	..	Tributary
Trig.	..	Trigonometrical/Branch
U S L.	..	Unemployed Supernumerary List
Uncov.	..	uncovenanted service
und.	..	undated
Univ.	..	University
unm.	..	unmarried
V C.	..	Victoria Cross
VP/in C.	..	Vice President/Council, Bengal
v.	..	see
Vrtcl.	..	Vertical
vol.	..	Vol/ume/unteer
W.	..	West
W I.	..	West Indies
wid/r.	..	widow/er
Wr.	..	Writer (or clerk)
y/r/st.	..	young/er/est

Dates: 22nd Aug. 1851 or 22-8-51. Editorial insertion: [...].
Number of page, consultation, or paragraph: (286).
Reference to page/place/of this volume: (286) [pl. 8]/of earlier volumes [I : 215, III, 418; pl. 12].

References to Publications

The Imperial Gazetteer of India of 1908 contains brief historical accounts of the provinces, districts, and cities of India, scattered through its 26 volumes, with a general summary in Vol. II. For other books of interest see volumes I to IV of these Survey Records.

A H Q Burma	General Staff Reports.
AJ	*Alpine Journal.* London. periodical.
AS B/Progs.	*Asiatic Society of Bengal/Proceedings*; Calcutta. annual from 1865.
Addiscombe	*Its Heroes & Men of Note*; H. M. Vibart. 2 vols. London. 1894.
Ain-i-Akbari	by Abul-Fazl; tr. and ed. by Gladwin. Calcutta. 3 vols. 1786; Jarrett & Sarkar, 1891–4; 1948.
Airy	*Autobiography of Sir Geo. ...Airy, ... A R.* by Wilfrid Airy. Cambridge. 1876.
Aitchison	*Treaties. ...* C. U. Aitchison. Calcutta. 1909.
Al Cantab.	*Alumni Cantabrigienses*, Part II, 1752–1900, 6 vols. J. A. Venn.
As R.	*Asiatic Researches.* Calcutta. annual till 1830.
BM. Cat. Pr.	*Catalogue of Printed Maps.* British Museum.
Balfour	*Cyclopaedia of India.* E. G. Balfour. Madras. 1857, 1 vol.; 2nd edn., 1871–81, 5 vols.
Ben. Dist. Gaz.	*District Gazetteer of Bengal.* occasional.
Ben Harkaru	Calcutta. periodical.
Ben P & P.	*Bengal Past & Present.* Calcutta. periodical.
Ben Sel.	*Selections from the Records of the Bengal Government.* Calcutta. occasional.
Ben Supply Regr.	*Supplementary Register of the Maps...of the Bengal Presidency.* Survey Committee, Calcutta, 1842.
Black	*Indian Surveys.* 1875–90. C. E. D. Black. London. 1890.
Blackwood	*Blackwood's Magazine.* Edinburgh. monthly.
Blue Book, Rev. Svys., NWP.	*Parliamentary Blue Book on Revenue Surveys; North-Western Provinces.* London. 1855.
Blunt	*List of Inscriptions...Christian Tombs... U.P.* E. A. H. Blunt. Allahabad. 1911.
Boase	*Dictionary of Modern English Biography.* Boase. London. 6 vols. 1892–1921.
Boeck	*Dutch Indian im Verschlossenland Nepal.* Kurt Boeck. Leipzig. 1903.
Bo Rev. Svys.	*Official Correspondence on the System of Revenue Survey*, Bombay. 1850.
Bo Sel.	*Selections from Bombay Government Records.* Bombay. occasional.
Br Ac Progs.	*Proceedings of the British Academy.* London. periodical.
Buchanan-Hamilton	*Account of the Kingdom of Nepal.* Francis Buchanan-Hamilton. London. 1819.
Bullock	*Historic Delhi.* Humphry Bullock. New Delhi. 1946.
Burke	Burke's *Peerage.* London. annual. All refs. to 101st. edn. 1956.
Burkill	*History of Botany in India.* chs. I to VII I. H. Burkill. *Journal Bo. Nat. Hist. Soc.*, 51, 1953; 54, 1956; 58–60, 1961–3.
Burke's *LG.*	Burke's *Landed Gentry.* London. periodical.
Burrard	*Mount Everest and its Tibetan Names. PP.* 26. S. G. Burrard. Dehra Dūn. 1931.
Burrard & Hayden	*Geography & Geology; Himalaya Mts. & Tibet.* S. G. Burrard & H. H. Hayden. 1st edn. 1908; 2nd. edn. to which refs. are made. Burrard & Heron Delhi 1933.
Burton	*Life of Sir R. F. Burton.* Thos. Wright. London. 2 vols. 1906.
Butler	*Travels & Adventures in...Assam.* John Butler. Calcutta. 1844.
Cadell	*Letters of Philip Meadows Taylor. ...* Patrick Cadell. Oxford Univ. 1947.
Cal Rev.	*Calcutta Review.* periodical.
Clan Fergusson	*Records of Clan Fergusson ...* J. & R. M. Fergusson. Edinburgh. 1895.
Clements Markham	*Mission of Geo. Bogle to Tibet*; with tr. of letter from Desideri. Markham. London. 1876.
Condon	*Indian Army Officers. Journal of the United Service Institute.* April 1947 (232–6). Simla.
Cotton, Evan	*Calcutta Old & New.* Evan Cotton. 1907.
Cotton, J. J.	*List of Inscriptions on Tombs in Madras.* J. J. Cotton. 1905.
Cotton, J. S.	*Encyclopædia of Islam*, I; *Baltistan*; Leyden. 1913.
County Families	*of the United Kingdom.* Walford. 1860.
Curry & Rice	by Geo. F. Atkinson. 5th edn. London. 1911.
DIB.	*Dictionary of Indian Biography.* C. E. Buckland. London. 1906.
DNB.	*Dictionary of National Biography.* 63 vols. with Index & Epitome. London. 1903/ *Supplements*, 3 vols. to 1940.
Dainelli	*Le Condizioni delle Genti Spezioni Italiana*; *de Filippi, 1913–4*; G Dainelli. Bologna. 1924.
Debrett	Debrett's *Peerage*, annual. London.
de Filippi	*Ippolito Desideri*; *an account of Tibet.* F. de Filippi. 1932–7.
Desh	Calcutta periodical, Bengali.
Dickens	*Report on the Survey Department of India.* C. H. Dickens. Calcutta. 1864.
Dist. Gaz. UP.	*District Gazetteers.* United Provinces. occasional.
Drew	*Jammu & Kashmir Territories.* Fredk. Drew. London. 1875.
Eighteen Fifty Seven	by S. N. Sen. Calcutta. 1957.
Ency Brit.	*Encyclopaedia Britannica.* edn. xiv, 1929, to which refs. are here made.
Englishman	Calcutta periodical.
F D Sel.	*Selections from Correspondence of Foreign Department, Govt. of India.* occasional.
Fatehgarh Camp	by C. L. Wallace. London. 1934.
Ferguson	*Kashmir. An Historical Introduction.* London. J. P. Ferguson. London. 1961.
Foster	*Catalogue of Paintings...in the India Office.* Wm. Foster. 5th edn. London. 1924.
Francke	*History of Western Tibet.* A. H. Francke. London. 1907.
Friends of India	Calcutta periodical.
Freshfield	*Round Kanchenjunga.* D. W. Freshfield. London. 1903.
G J.	*Geographical Journal.* R. G. S. London. monthly from 1893.
G R.	*General Report on the Operations of the Survey of India*; annual from 1878–79.
G R Rev.	*General Report, Revenue Surveys, LP. Bengal Presidency.* at 1 to 3 year interval 1852–61 and then annual to 1877.
G R Topo.	*General Report Topographical Survey.* annual 1860 to 1877; combined with *GR Trig.* 1864–5.

References to Publications

G R Trig.	*General Report...Trigonometrical Survey of India.* periodical 1857 to 1877.
GTS.	*Account of the Operations of the Great Trigonometrical Survey of India.* Dehra Dūn. 19 vols.; I, 1860; XIX 1907.
GTS. Syn.	*Synoptical Volumes of GTS.* Dehra Dūn. 35 vols., 1874 to 1909.
GTS. Trig.	*Triangulation Pamphlets.* pub. by Degree Sheets. GTS. Dehra Dūn.
Gastrell	*Geographical...Report of the Districts of Jessore...and Backergunge.* J. E. Gastrell. Calcutta. 1868.
Geo. Everest	*Measurement of a Section of Arc.* Geo. Everest. London. 1830.
Geo Mag.	*Geographical Magazine.* London. periodical from 1874.
Geod R.	*Geodetic Report, ... Survey of India.* periodical from 1922.
Gill	*History of the Royal Observatory. Cape of Good Hope.* David Gill. London. 1913.
Godwin-Austen	*Vocabulary of Kashmiri & Balti languages.* H. H. Godwin-Austen. *JASB.* XXXV, July 1866.
Grierson	*Linguistic Survey of India.* G. A. Grierson. London. 1900.
Gulatee	*Mount Everest; Its Name & Height. TP.* 4. B. L. Gulatee. Dehra Dūn. 1950. *Height of Mt. Everest* 1954. *TP.* 8.
H J.	*Himalayan Journal.* Oxford. annual from 1928.
Harleian Soc.	*The Publications of the Harleian Society, occasional. London.*
Hirst	*Notes on the Old Revenue Surveys of Bengal... & Assam.* F. C. Hirst. Calcutta. 1912.
Hirst	*The Surveys of Bengal.* 1917. F. C. Hirst. Calcutta.
Hirst (*Calcutta*)	*Brief History of the Large-Scale Surveys of Calcutta & its Neighbourhood.* 1903 to 1904. with Maps.
Hirst & Smart	*Surveys of the Coalpard District.* F. C. Hirst & A. B. Smart. Shillong. 1917.
Hobson-Jobson	by Henry Yule & A. C. Burnell. London. 1886; 2nd edn., 1902.
Hodson	*Officers of the Bengal Army, 1758–1834.* V. C. P. Hodson. London. 4 vols. 1927 to 1947.
Hooker	*Himalayan Journals.* J. D. Hooker. 2 vols., London. 1854.
Howard-Bury	*Mount Everest; The Reconnaissance,* 1921. C. K. Howard-Bury. London. 1922.
Hunter	*The Figure of the Earth.* J. de Graaff Hunter. 15th Indian Science Congress. Calcutta. 1928.
	Refraction Formulæ. TP. 14. Hunter. Dehra Dūn. 1913.
	Mt. Everest. RAS ON., 3/15, 1953; *GJ.* cxxi, 1855.
I H R C.	*Report of Indian Historical Records Commission.* periodical.
I L N.	*Illustrated London News.* London. weekly.
IO Cat.	*Catalogue of Maps...of the Indian Surveys. ...* India Office. London. 878.
Imp Gaz.	*Imperial Gazetteer of India.* 26 vols. Oxford. 1908.
Imp Lib M & P.	*Catalogue of Maps & Plans, ... Imperial Library.* Calcutta. 1901.
Indian Archives	*The Indian Archives.* Delhi. periodical.
Indian Railways	*History of Indian Railways.* Simla. periodical.
Izzut Ullah	*Travels in Central Asia, 1812–3.* Mir Izzut Ullah. tr. by P. B. Henderson. Calcutta. 1872.
JASB.	*Journal of the Asiatic Society of Bengal.* Calcutta. annual from 1832.
JMLS.	*Journal of the Madras Literary Society.* periodical.
JRGS.	*Journal of the Royal Geographical Society.* London. monthly 1831–80.
JUSI.	*Journal of the United Services Institute (India).* periodical.
K & J. Admin.	*Administration Report, Kashmir & Jammu.* Periodical.
Kashmir Routes	*Route Book.* 8 vo. 24 pp. *with Route Map of Western Himalayas. ...* T. G. Montgomerie. Dehra Dūn. 1872. 2nd edn. 1883.
Keene	*A Servant of John Company.* H. G. Keene. London. 1897.
Kenneth Mason	*Johnson's Suppressed Ascent of E.* 61. from *AJ.* Nov. 1921. Kenneth Mason.
Knight	*Where Three Empires Meet.* E. F. Knight. London. 1891.
Ladak	*with...Surrounding Countries.* Alex. Cunningham. London. 1854.
Lang	*Diary & Letters of A. M. Lang, 1857–9. Journal of Soc. ... Army Historical Research.* Nos. 35–6; vol. IX. 1930.
Leitner	*Dardistan.* G. W. Leitner. London. 1914.
Letters Edifiantes	*Letters Edifiantes et Curieuses.* 34 vols. Querbœuf. Paris. 1702–41; 2nd edn. 2 vols. 1849.
Log. Tables	*Logarithm Tables.* Robt. Shortrede. 1st edn. Edinburgh 1844. 2nd edn. 2 vols. 1849.
Lotus Walker	poem by James Abbott; pub. with Introduction, London, 1853, under title *Tales of the Forest.*
M R A S.	*Memoirs of the Royal Astronomical Society.* London. periodical.
Mackay	*Western India.* A. Mackay. 1853.
Mad. Sel.	*Selections from the Records of the Madras Govt. ... relating to the General Revenue Survey.* No. I, 1855 (1–123); LIII, 1858; LXXIV, 1863. Madras.
Mad. Admin.	*Madras Manual of the Administration.* vol. I. 1885.
Madras Routes	*Routes in the Peninsula of India.* Madras. Feb. 1853.
Mad. Services	*Services of Madras Officers.* half-yearly.
Maldah	*Geographical & Statistical Reports of the District of Maldah.* J. J. Pemberton. Calcutta. 1854.
Map Lists	*Engraved & Lithographed Maps of the Survey of India.* SGO., Calcutta. periodical from 1861.
Markham	*A Memoir on the Indian Surveys.* Markham. London. 1st edn. 1873. 2nd edn., to which refs. are here made, 1878.
Markham's *Abstract.*	*Indian Surveys,* occasional from 1869–70. London.
Mason	*Abode of Snow.* Kenneth Mason. London. 1955.
Mathl. Tables	*Mathematical Tables.* Chas. Hutton. 1st edn. Woolwich, 1785. 5th edn., 1811.
Meridl. Arc	*An Account of...Two Sections of the Meridional Arc of India.* Geo. Everest; 2 vols. London. 1847.
Modern Rev.	*The Modern Review.* Calcutta. periodical.
Mount Everest	by H. C. B. Tanner. Calcutta. 1890.
N F Atlas	*Atlas of the Northern Frontier of India.* New Delhi. 1960.
NWP. Directions	*Directions for Revenue Officers in the NWP.* J. A. Thomason. Agra. 1849.
NWP. Sel.	*Selections from the Public Correspondence of...the N.W.P.* Agra. 1846 and occasional.
Nature	London. periodical.

References to Publications

Neve, Arthur	*Thirty Years in Kashmir.* Arthur Neve. London. 1903.
Neve, Ernest	*Beyond the Pir Panjal.* Ernest Neve. London. 1912.
Notable Record	*A Notable Record.* F. Joubert de la Ferté. London. 1826.
Notes & Queries	London. periodical.
O W.	*The Record of Old Westminsters.* Barker & Stenning. 2 vols. London. 1925.
O'Byrne	*Dictionary of Naval Biography.*
Ocean Highways	Survey Reports etc. 1871–2, ed. C. R. Markham, pub. SSI. 1873.
Oldham	*Manual of Geology in India.* R. D. Oldham; *Structure of Himālayas & of Gangetic Plain.* GSI. Calcutta. 1893.
O'Malley	*District Gazetteers, Bihar & Orissa. Patna; Saran.* S. S. O'Malley. Patna. 1926.
P P.	*Professional Papers of the Survey of India.* Dehra Dūn. occasional.
P R.	(*Parliamentary*) *Report on the Great Trigonometrical Survey of India.* A. S. Waugh. London. 1850.
Paget & Mason	*Records of the Expeditions against the N.W. Frontier Tribes.* Paget & Mason. London. 1884.
Pannikar	*The Founding of Kashmir State.* K. M. Pannikar. London. 1954.
Parker	*A Forest Flora for the Punjab & Delhi.* R. N. Parker. Lahore. 2nd edn. 1924.
Pettermann's *Mittheilungen*	Leipzig. periodical.
Phil Trans.	*Philosophical Transactions of the Royal Society.* London. periodical.
Pioneer	Allahabad. periodical.
Prabasi	Calcutta periodical; Bengali.
Practical Surveying	*Treatise of, ...* R. Gibson. London, 1767; new edn., Trotter, Dublin. 1839.
Punjab Admin.	*General Report upon the Administration of the Punjab Proper. ...* 1849–50 & 1850–51. Calcutta. 1853.
Punjab Inscr.	*Inscriptions on Christian Tombs. ... Punjab.* G W. de Rhé-Philipe. Lahore. 1912.
Punjab Sel.	*Selections from the Records of the Punjab Govt.* Lahore. occasional.
Q J G S.	*Quarterly Journal of Geological Society.* London.
R A S (mn)/ ON	*Monthly Occasional/Notes/Royal Astronomical Society.*
R G S Progs.	*Proceedings of the Royal Geographical Society.* London. annual from 1859.
R E J.	*Royal Engineers Journal.* Chatham. monthly.
R S Progs.	*Proceedings of the Royal Society.* London, monthly 1859–62. *v. GJ.*
Raja tarangini	*A Chronicle of the Kings of Kashmir.* trn. & Commentary. M. A. Stein. London. 1900.
Rectangulation	*PP.* 21. Dehra Dūn. 1927.
Regr. of Maps Bombay.	*Register of Maps,* Bombay Record Office.
Remusat	*Recherches sur les langues Tartares.* J. P. A. Remusat. Paris. 1820.
Rennell	*Memoir of a Map of Hindoostan.* James Rennell. London. 1st edn. 1783; 3rd edn. 1793 [I: XIX, sv. *Memoir*].
Rev Svy. (India)	*Return to the House of Common; Report on Settlement of N.W.P.* London. 1853.
Rev Svy. N.W.P.	*Reports on the Revenue Settlement of the N.W.P.* 2 vols. 1862. (*v. Blue Book*).
Roorkee Papers	*Professional Papers on Indian Engineering* Roorkee. annual. from 1863–4.
S A Series	*Southern Asian Series. Maps of* S of L scale 1/2 M.
S I Lists	*List of Officers of the Survey of India.* Calcutta. half-yearly from 1872.
S I News	*Survey of India Monthly News Letter.* Dehra Dūn. monthly from 1947.
S I Notes	*Monthly Notes.* Calcutta. 1891 to 1945.
S I Pubns.	*Publications of the Survey of India.* Dehra Dūn. occasional.
S I Records	*Records of the Survey of India.* Calcutta or Dehra Dūn. periodical from 1912.
S I Services	*Services of Officers of the Survey of India.* half-yearly from 1880.
Saharanpur	*Dr. Geo. Govan & the Saharanpur Botanical Gdns.* H. Montgomery-Hyde. from *JR C. As. Soc.* Jan. 1962 (47–57).
Sandes	*The Military Engineer in India.* E. W. C. Sandes. 2 vols. Chatham. 1933–5.
Sarkar	*I H R C.* XXX (11), 1955 (686–95). *Godwin-Austen's Map of Bhutan.* U. N. Sarkar.
Sc Geo Mag.	*The Scottish Geographical Magazine.* Edinburgh. periodical.
Schlagintweit	*Results of a Scientific Mission to India & High Asia, 1854 to 1858.* Schlagintweit Leipzig. 1861–2.
Settmt. of DDn.	*Report on the Settlement of Dehra Dūn.* A. Ross. 1850.
Shaw & Smart	*A Brief History of the Survey of Sylhet District.* T. Shaw & A. B. Smart. Shillong. 1917.
Sherwill	*Report on the Rivers of Bengal & Damoodah Embankments.* W. S. Sherwill. *Ben. Sel.*, XXIX. Calcutta. 1865.
Simms	*Report on the Survey of Calcutta.* F. W. Simms. *Misc. Papers.*, V; Calcutta. 1851.
Simla Hill States	*Simla & the Simla Hill States...*1815–1835. H. Montgomery- Hyde. Lahore. 1961.
Statesman	Calcutta & New Delhi. daily newspaper.
Stein	*Ancient Geography of Kashmir. JASB.* LXVIII, 1899; extra II.; *v. Raja Tarangini* Orphan Press, Calcutta, 1851.
Strachey	*Physical Geography of Western Tibet. JRGS.* XXIII (1), 1853; and separately 1854.
Sven Hedin	*Southern Tibet.* Sven Hedin. 9 vols. 1917; Mount Everest. 1926.
T P.	*Technical Paper, Survey of India.* Dehra Dūn. occasional.
Tarikh-i-Rashidi	by Mirza Muhd. Haidar, c. 1540; tr. Denison Ross; ed. Ney Elias. 1895; 2nd edn. 1898.
Tarikh Jammo	by Aza Hussmat Ullah Khan. Lucknow. 1939.
Tel Report	*Report on Telegraph Dept.* occasional Calcutta.
Thackeray	*Biographical Notices of Officers of the Royal... Engineers.* Edw. Thackeray. London. 1900.
Timely Retreat	by Miss Wallace Dunlop. 2 vols., Bentley, London. 1858.
Times	*The Times.* London. daily newspaper.
Thomson	*Travels in Western Himalayas in Tibet.* Thos. Thomson. London. 1854.
Thuillier & Smyth	*Manual of Surveying for India.* H. L. Thuillier & R. Smyth. Calcutta. 1851. 2nd edn. London 1855; 3rd edn. Calcutta, 1875.
Tieffenthaler	*Description Historique et Geographicue de l'Inde.* Joseph Tieffenthaler. Paris 1791.

References to Publications

Topo. Handbook	*Survey of India Handbook of Topography.* part v; *Planetabling.* 4th edn. 1935. Calcutta.
Topo Instns.	*Instructions for Topographical Surveying.* A. S. Waugh. Roorkee, 1853 & 1861. v. Thuillier & Smyth, 2nd edn., appx.
Trans. RAS.	*Transactions of the Royal Astronomical Society.* London. periodical.
Trav Tables	*Traverse Tables.* J. T. Boileau. London. 1839; J. F. Egerton, 1838; Robt. Shortrede, London. 1863; Edinburgh, 1864.
Treatise of Practical Surveying.	by R. Gibson, London. 1767; new edn. by Trotter, Dublin. 1839.
Trig. Instns.	*Practical Instructions for conducting Trigl. Svy. Operations.* A. S. Waugh. Dehra Dūn. 1865. *Roorkee Papers,* IV (303–16, 413–22).
Ubique	*War Services...of Officers of...Bengal Army.* T. C. Anderson. London. 1863.
Vibart	*Military History of the Madras Engineers.* H. M. Vibart. 2 vols. Madras. 1881–3.
Vigne	*Travels in Kashmir...and...the Himalayas.* G. T. Vigne. 2 vols. London. 1842.
Waddell	*Among the Himalayas.* L. A. Waddell. London. 1899; 2nd edn. 1900.
Who was Who	vol. I, 1897–15. London. 1920; vol. IV. 1941–50.
Wood, I	*Nomenclature of the Himalayan Peaks. ... Nepal.* Uncl. P. 2., Report on the identification and nomenclature of the Himalayan Peaks as seen from Katmandu-Nepal. Henry Wood. Calcutta. 1904.
Wood, II	*S I. Records,* VIII A, *Explorations in the Kara Koram...with the De Filippi Scientific Expedition of 1914.* Henry Wood. Dehra Dūn. 1922.
Yule	Travels of Marco Polo. Henry Yule. 2 vols. London. 1871.

CHAPTER I

GENERAL NARRATIVE

Notable Events — GREAT TRIGONOMETRICAL SURVEY ; *North-East — North-West — Spirit Levelling* — TOPOGRAPHICAL SURVEYS — REVENUE SURVEYS ; *Bengal ; Lower Provinces — Upper & Central Provinces — Punjab — Bombay & Sind — Madras* — MAPS — CONCLUSION.

THIS period, 1844 to 1861, covers the years during which Andrew Waugh held office as Surveyor General and Superintendent of the Great Trigonometrical Survey of India.

His illustrious predecessor, George Everest, had seen the completion of the great central arc up to the Himālaya — longitudinal chains to Calcutta and Bombay—and three subordinate meridional series to the east of the great arc. It fell to Waugh to complete the grid of triangles over Bengal, Bihār, and Orissa, with extensions towards the north-east frontier, and down the east coast. After the occupation of the Punjab, the main triangulation was carried westward to the Indus, and northwards through the mountain regions of Kashmir, whilst the Bombay triangulation was continued west and north to link up.

The topographical surveys of Hyderābād and Ganjam were reorganized and extended, and new surveys carried out over the north-west Himālaya, Kashmir, and parts of the Punjab.

District revenue surveys were continued under the Deputy Surveyor General at Calcutta, in Bengal, Bihār, and Assam, and later extended into central and upper India and the Punjab. The revenue surveys of Bombay progressed steadily under control of the local government and a start was made on new revenue surveys in Sind and Madras.

The more important political events of this period were the Sikh wars of 1846–9, which led to the British occupation of the Punjab and the assignment of Kashmir to Gulāb Singh, the Dogra ruler of Jammu. British rule was further extended to the city of Rangoon and the province of Pegu following the Burmese war of 1852–4, and to the territories of Nāgpur and Oudh by their annexation in 1853 and 1856.

The mutiny of the Bengal army broke out at Meerut in May 1857, and though the main armies of the mutineers were defeated at Delhi in September and at Lucknow in November, disturbances and military operations persisted into the following year over a wide area. The revenue survey party at Jhānsi was entirely wiped out, and in other areas survey was suspended and parties diverted to safer regions. The most important sequel was the passing of the old East India Company, "John Company", and the transfer of power to the British Crown through the agency of a Viceroy.

Amongst notable changes during these eighteen years were the start of the railways—the electric telegraph—the geological survey—and the meteorological department, all of which affected the Surveyor General's department in one way or another, especially in competition for educated staff.

GREAT TRIGONOMETRICAL SURVEY ; NORTH-EAST

The triangulation completed during Everest's period had been the Great Arc, the Calcutta and Bombay longitudinal series, the Budhon, Ranghir, and Amua meridional series with short sections connecting their northern extremities. A start had been made on the Karara series, and at the end of 1843 parties had

taken the field for Chendwar, Gora, and Calcutta. The programme provided for ten of these intermediate series running north from the Calcutta Longitudinal to the hills at about one degree interval, and the last was completed by 1852.

The North-East Longitudinal connecting the northern stations along the foot of the hills was carried out piecemeal by a number of observers between 1844 and 1852, and it was from stations of this series that observations were taken to fix the positions and heights of the snow peaks. At the end of 1847 a base-line was measured at Sonakhoda in Purnea at the junction of this series with the Calcutta Meridional, which closed the North-East quadrilateral. Secondary and minor work was carried out regularly for survey of the major rivers, for fixing towns and cities, and to provide geographic control for the revenue surveys.

The most successful surveyor was George Logan who completed the Chendwar series and an important section of the North-East Longitudinal. Two good officers died, William James and Reginald Walker.

Triangulation south of the Calcutta Longitudinal was started in 1845 by Thorold Hill, who extended the South Maluncha series towards Balasore, and then started the East Coast series from the Calcutta base-line. This ran through most difficult unhealthy country, "covered with groves and intersected with creeks and marshes". Hill's health broke down, and the series was carried southwards by a succession of officers. A base-line of verification was measured at Vizagapatam in 1862.

At the end of 1852 a longitudinal series was commenced near the Sonakhoda base, to run eastward through Assam. By 1856 Nicolson had extended it some 200 miles, being hampered by swampy fever-ridden country. In 1857 he was relieved by Charles Lane, who carried on with increasing difficulty and expense until in 1860 the longitudinal series was broken off near Gauhāti, and the party turned south across the Khāsi Hills to start the East Frontier series through Cherrapunji and Sylhet.

GREAT TRIGONOMETRICAL SURVEY; NORTH-WEST

After the defeat of the Sikhs in 1846, there was urgent call for triangulation to be carried into the Punjab to control military and revenue surveys, and by the end of 1852 four survey parties had been shifted into the new area.

In 1847 Du Vernet moved up from the Gurwāni series to start the North-West Himālaya series, which was to run westwards along the foothills from the Great Arc near Dehra Dūn, through Sirmūr, Hoshiārpur, Kāngra, and Jammu to Attock. Some of his assistants were employed on topographical survey northwards to the snowy range, over districts lately occupied by the Sikhs. By 1849 the principal triangles reached Jammu territory but were abruptly stopped by local objection to the occupation of a sacred hilltop.

Work was resumed in 1850 by Logan who had completed his work to the east, and took over the main triangles from Du Vernet who now concentrated his party on the topographical survey. Logan's party was re-designated the 2nd Hill series, and by the end of 1851 had completed the North-West Longitudinal up to the Indus at Attock, in the neighbourhood of which the Chach base-line was measured during season 1853–4.

In 1848 Renny-Tailyour brought the North Maluncha party to Central India to start work on a longitudinal series running west from Sironj to Karāchi in extension of the Calcutta series. This Great Longitudinal series was of major importance for control of the several meridional series that were to run southwards through the Deccan and Gujarāt and northwards through Rājputāna.

During 1849 Renny-Tailyour was relieved by Strange who carried triangulation across the rough Aravalli hills and "the little desert" to close at Karāchi in April 1853. The passage of the desert, 150 miles of interminable sandhills, raised serious problems—supplies—scanty brackish water from wells often 300 feet deep—lack of building material for towers and platforms—mirage and other vagaries of

refraction—"a miserable country only interesting from its physical deficiences". William Rossenrode was a tower of strength, and did noble work laying out the approximate series in advance.

To complete the perimeter of these north-west triangles, the Karāchi and Chach base-lines were connected by the Great Indus series. This was commenced from the north by Logan in 1852, and from the south by Tennant who took over charge of Strange's party at Karāchi during 1853. Progress was interrupted by the call for triangulation required by the Punjab revenue surveys, but from 1857 work was pushed on from both north and south under the general supervision of James Walker, till the whole series, 750 miles long, was completed early in 1860.

Meanwhile the interior meridional series, Rahun, Gurhagarh and Jogi-Tila, were carried south through Ludhiāna, Jullundur and Jhelum, whilst the Sutlej series followed that river from its junction with the Indus to the neighbourhood of Ferozepore. These were all completed between 1852 and 1863. The Rahun and Gurhagarh series passed through wide areas of desert where tower-building presented many difficulties. Triangles had to be laid out with scrupulous regard for symmetry, with sides of between nine and twelve miles. Important places were connected up by secondary triangles.

The Kashmir triangulation was started by Montgomerie in 1855 from the neighbourhood of Jammu, and extended across the Pir Panjāl to the great Himālaya range, fixing the peaks of Nanga Parbat and K2. In 1859 Johnson and Beverley both observed from stations over 19,900 feet above the sea. Other sections were employed on topographical triangulation and planetabling.

From 1844 to 1853 the Bombay triangulation was extended widely by Harry Rivers. After taking the South Konkan series south to Goa, he worked the North Konkan, or Singhi, series northwards until held up by calamitous fever in the forests of Rājpipla. He then shifted ground to carry the Khānpisura series north through the Deccan to join Renny-Tailyour near Nīmach. From here he worked his triangles north to Ajmer, to form the Arāmlia series that was later incorporated with the Gurhagarh.

From 1851 he worked south from Abu into Gujarāt and Kāthiāwār, and in March 1853 took furlough leaving the party under charge of Nasmyth, who was later followed by Haig.

SPIRIT LEVELLING

From discrepancies found in the heights brought up by triangulation from various connections with sea-level, it became clear that—except through hilly country—more accurate values would be derived by spirit level. To provide, therefore, a reliable datum for all upper India triangulation and for spot heights to control engineering and irrigation projects, Waugh decided to bring heights from the sea at Karāchi by a line of spirit levels up the Indus valley.

A tidal station was established at Karāchi, and between 1858 and 1860 Walker ran a connected line of spirit levels to the base-line at Chach. The patterns of instruments and the detailed procedure introduced by him were so successful that little change had to be made during the extensive operations of the next fifty years.

TOPOGRAPHICAL SURVEYS

Everest had concentrated all his efforts on the trigonometrical survey, firmly refusing to initiate any new topographical surveys and, when Waugh took over charge, the Hyderābād survey—that of the Nizām's Dominions—was the only one in progress. Henry Morland held charge until his promotion to major in 1848, and work then continued for two years under a Madras military officer of no

survey qualifications, until the Surveyor General had the work closed down till he could find a suitable professional officer. In 1855 James Mulheran, who had done excellent work on the Himālaya topographical survey, was appointed to raise the party anew, and the survey, started in 1816, was brought to a close in 1866. Much of the area surveyed was beyond the control of the G.T.S., and triangulation had to be extended widely by officers of the field party.

The irregular survey that Hill had long carried out in the wilds of Ganjam under the orders of the Madras Government had fallen into temporary abeyance on his departure on furlough in 1841. It was resumed in 1843 by John Halpin and came under the Surveyor General's orders the following year. Halpin had no professional experience, and work dragged on with no proper control till his death in 1848, and then till 1850 when George Saxton took over charge after several months training with the Coast Series. The party was now moved north into the Orissa States where work could be connected to the trigonometrical survey, and quality gradually improved. Progress was slow owing to the unhealthiness of the thickly wooded hills and to the consequent shortness of the field seasons that had to be confined to the comparatively safe period January to April.

In 1854 a second party was formed under Depree, and better progress was made, though interrupted for a season by the 1857 mutiny. Orissa was completed by 1860 when Depree moved into Chota Nāgpur and Saxton to the wild country south of Sambalpur.

After the Sikh wars a large area of little-known country came under British administration, and military frontier surveys were started by two young Engineer officers. Robinson surveyed the hill district of Hazāra lying between the Indus and Kashmir, north of Rāwalpindi, whilst James Walker surveyed the trans-Indus districts of Peshāwar, Kohāt, and Bannu under almost active service conditions. The surveys were of necessity in the nature of rapid reconnaissance, but both officers did so well that the Surveyor General welcomed their transfer to his immediate control and the connection of their surveys to the G.T.S.

During season 1850–1 Robinson surveyed the boundary between the territories of Maharāja Gulāb Singh and the British districts between the Rāvi and Jhelum, and he then took up a one-inch survey of the Jhelum and Rāwalpindi districts. Triangulation was based on Logan's triangles of the North-West Himalaya series, and the survey extended south to include the broken country of the Salt Range.

Under the Surveyor General's close direction, Robinson developed a high standard of work, and his survey became the model of topographical survey for the next fifty years. His note on planetabling stood in the departmental handbook for even longer. There was, however, no rigorous contouring, and clinometer heights had not yet arrived. The party was considerably strengthened in 1853 by the posting of John James, an exceptionally fine draughtsman, and it later became the regular practice for some of the planetablers to spend the cold weather with Robinson, and the summer with Montgomerie in Kashmir. Robinson's party was considered the ideal training unit.

Field work was completed in May 1859, and the maps and charts were submitted after October 1860, when part of the establishment left to take up the survey of Gwalior. There had long been a demand from the civil authorities of Central India for better maps for revenue and administrative purposes, as well as for railway and other engineering works.

From 1855 to 1859 Henry Johnstone was engaged on the revenue survey of the trans-Indus area of Derajāt, which developed into a topographical survey of the whole tract from Mithankot northwards to overlap Walker's survey of Bannu. Johnstone possessed all the boldness and tact of a successful frontiersman, and with a military guard he surveyed well up into the foothills without any serious clash with the wild independent tribesmen.

From 1847 several of the assistants on Du Vernet's North-West Himālaya series were employed on half-inch planetable survey which reached well into the plains

on the south, and northwards to the snowy range, extending over the hills from Garhwāl westward to Chamba, and the Jammu border. Work was based on long winding chains of minor triangulation with frequent stations of over 18,000 feet above the sea. Mulheran, Keelan, George Shelverton, and Johnson particularly distinguished themselves. On Du Vernet's transfer to Assam at the end of 1852 the party continued under Mulheran, who succeeded with Johnson in connecting the Sutlej triangulation north of the great range with that of the upper Ganges to the south.

Early in 1855 the party was taken over by Montgomerie for survey of Gulāb Singh's dominions stretching north from Jammu across Kashmir to Ladākh. With Douglas and Johnson, he took a series of principal triangles across the Pir Panjāl into the Kashmir valley. Next season more officers and assistants were posted for topographical work, and three infantry officers of the Quarter-master-General's staff accompanied the party for planetable sketching. Unfortunately these officers could not be reposted, and in 1857 other officers had to be instructed from the start, all of whom, however, including Godwin Austen, proved excellent surveyors, and remained many years with the department.

Each year the party marched up from Dehra Dūn in the spring, to commence survey about the end of April. It left the valley before the end of November "just as the snow began to fall on the low hills", and marched back to Dehra for the cold weather. Work went on during 1857 without check from the terrible happenings of distant India. Gulāb Singh, who had warmly encouraged the survey, died during this year, and his son, Ranbir Singh, was equally friendly.

The first map of the Kashmir valley was submitted in 1859, and work was then advanced on the ¼-inch scale into Ladākh. Godwin Austen who had missed two seasons returned in 1860 to work on the Karakoram range, his planetable survey of the glaciers of K2 and other peaks being a notable piece of work. The strength of the party was now gradually reduced, and at the end of 1864 Montgomerie took furlough after thirteen successive field seasons. Work was finally closed on the Khotān frontier in 1865.

For the war with Burma, 1852–3, the British army had no map of any practical value. At the end of the war an Engineer officer of no previous survey experience was appointed Superintendent of Survey, Pegu, with orders to produce a quarter-inch map "as quickly as possible". Assisted by a few military officers, and with a number of Burmese and Karen boys locally instructed, he started a rough survey based on a network of theodolite traverses, and filled in by compass routes. In 1855 he sent in a general sketch map on the 8-mile scale which was printed at Calcutta. He was then followed by one officer after another, and much of the earlier work was superseded by work of similar character. It was not until 1863 that the survey was put under the orders of the Surveyor General, now Henry Thuillier, to whom the first quarter-inch sheets were at last submitted, and he had to report that the survey had "no pretensions to scientific accuracy". The final maps were finished off at Madras, and submitted in 1866. A regular survey of Lower Burma had to await the arrival of the Great Trigonometrical Survey some ten years later.

REVENUE SURVEYS: BENGAL

Though four of the Bengal district revenue surveys were allowed to run on, the greater number, including all those of the North-Western Provinces, had been closed down during 1842. Rigid economy had been forced on the country by the expense of the Afghān wars. The four parties kept on were those of Patna—Gaya—Purnea—in Bihār, and Midnapore in Bengal.

The Patna party moved north to Sāran in 1843, and then, under Alexander Wyatt, surveyed in turn Champāran and Tirhut, still in Bihār. On completing these in 1849 it was transferred to Eastern Bengal, working first in Mymensingh

and then in Dacca. Wyatt's health broke down and he died in 1857. By 1861 the party was working in Tippera District.

The Gaya party continued for the next ten years under charge of Walter Sherwill, surveying Shahābād, Bhāgalpur, Birbhum, and Murshidābād. From 1853 Sherwill was put on special duty to revise the district and lesser administrative boundaries, and Gastrell carried work westward through Khulna and Jessore to the Meghna River.

Charge of the Purnea party was taken over in 1845 by James Pemberton, who worked eastward through north Bengal. After his death in 1860 the party moved further east into Sylhet.

After Mathison left Midnapore in 1844, one of his assistants spent the next two years clearing up discrepancies, whilst another took the party first into Hooghly, and then into the 24-Parganas. In 1847 charge was taken over by the very capable and experienced surveyor Ralph Smyth, who completed at the same time the survey of the suburbs of Calcutta that had been started in 1841. After surveying Burdwān and Nadia, Smyth retired in 1857, and two years later the party moved under James Sherwill to take up the survey of Manbhum in contact with that started in Chota Nāgpur.

As all these surveys fell in districts that had been subject to the permanent settlement of 1793, survey was confined first to the external boundaries of the permanently settled estates, but for lands outside these estates full survey was made, not only of village boundaries, but also of the limits between forests, waste lands, and the various classes of cultivation. In some areas also the field-to-field survey of village lands, known as *khasrah*, was specially ordered.

The survey programme of each party was controlled by a civilian Superintendent of Survey, corresponding to the modern Settlement Officer, assisted by a number of deputies whose duties included the laying down and settlement of boundaries and the assessment of revenues. There was much controversy as to the respective advantages of managing the *khasrah* by the professional surveyors or by the settlement staff, and from 1851 it was definitely transferred to the latter at some expense of accuracy. Professional administration rested with the Deputy Surveyor General who was responsible to the Sadr Board of Revenue, Lower Provinces. From 1847 this office was held by Henry Thuillier, who in 1861 succeeded as Surveyor General.

UPPER & CENTRAL PROVINCES

At the end of 1847 a party was raised by Donald Vanrenen for the revenue survey of the British territories of Ajmer and Merwāra in Rājputāna. Work was completed in a single season, and the party then moved to take up an extensive survey along the northern borders of Rohilkhand, which had not been satisfactorily completed before 1842. A detachment under Francis Burgess spent two seasons on a four-inch survey of Delhi city and country to the south.

The Rohilkhand area was covered with *sāl* forest, high grass, and swamps, and special lines of level were run to facilitate drainage works. In 1853 the party under Burgess was transferred to Bundelkhand and met with a tragic end in 1857. Vanrenen's party was transferred to Jubbulpore, and continued work in the Central Provinces for several years.

During 1854 a new party was raised by John Blagrave for work in the Saugor District, and continued under other officers as a second party in the Central Provinces. A third party, also raised in 1854 for survey round Nimach, was moved successively to Bharatpur, Bundelkhand, and then under Adrian Vanrenen to the Central Provinces.

In 1859 work was started in Oudh by the transfer of Anderson's party from the Punjab, and in 1860 a second party was raised by Donald Vanrenen.

At the close of the first Sikh war in 1846 the British took over the Jullundur *doāb* bounded by the Sutlej and Beās rivers, and orders were issued for raising two parties for the revenue survey of the trans-Sutlej and cis-Sutlej areas.

The cis-Sutlej party was raised by Henry Stephen, who had learned his survey in the North-Western Provinces under Henry Lawrence. The survey fixed the boundaries and main topographical features of the protected Sikh states, with the village boundaries of Ambāla, Hissār, and other British districts. In 1851 Stephen handed over to Robert Shortrede, who moved the party west to Siālkot in the Rechna or Rāvi–Chenāb *doāb*. Stephen's work had been carried out in the hasty manner of the later N.W.P. surveys, and much had to be revised by an assistant left for the purpose for the next three years.

After the first season the trans-Sutlej survey passed to the charge of Thomas Blagrave, who completed the Jullundur and Hoshiārpur districts and extended survey well into the Kāngra hills, making junction with Du Vernet's topographical survey. Field survey was brought to a close in 1852, when the party was moved to Lahore to take up work in the lower Rechna *doāb*.

After the close of the second Sikh war, and the proclamation of the whole Punjab as a British province from March 1849, orders were issued for the raising of a third party for the survey of the Bāri *doāb*, enclosed between the Beās and Rāvi rivers. This was formed from the other two parties, and under John Blagrave commenced work in Gurdāspur in October 1850. Survey of Multān District to the south was completed in 1858 and the party was then moved to the survey of Chota Nāgpur.

In 1851, Shortrede brought up the cis-Sutlej party to the Rechna *doāb*, starting from Siālkot in the north, whilst the following year Thomas Blagrave brought up the trans-Sutlej party to Gujrānwala to the south. In 1855 the survey was completed, and the southern party was transferred to Sind under John Macdonald, whilst Shortrede moved the northern party across the Jhelum to take up work in the southern districts of the Sind–Sāgar *doāb*, having in the meantime completed Shāhpoor in the Jech *doāb*.

The Sind–Sāgar *doāb* is that bounded by the Jhelum and Indus rivers. The rugged northern districts, Rāwalpindi and Jhelum, being under one-inch topographical survey by Robinson, and a large area south of the Salt Range being sandy desert, or *thal*, revenue survey was confined to the fertile riverain tracts, and these were completed by 1858, when the party was moved to Oudh under charge of Francis Anderson.

On the whole, these Punjab surveys, and the maps produced from them, were of a higher quality than the earlier ones of the North-Western Provinces.

BOMBAY & SIND

The Bombay revenue surveys continued on the same principles as worked out by Goldsmid and Wingate, and described in volume IV of these Records. They were devoted entirely to fiscal needs, with full records and plans for each village, each district survey being self-contained, without geographical control. It has been claimed that this system was "the best and most perfect for revenue purposes", but it was useless for topographical or general mapping purposes.

The Bombay Government could not be persuaded to follow the Bengal system, and to spend time and money on connecting up their village surveys by sound triangulation and well designed traverses. They were quite satisfied with such topographical maps as were left to them by the old Deccan survey of 1820 to 1830, and claimed that their more particular attention to the village survey gave "with greater fidelity and minuteness those interior sub-divisions of each village" required by the revenue officers. Reliable village maps and their associated records were the great purpose of the survey, and from 1849 these maps were regularly lithographed.

The survey continued to be conducted by military officers who were not so much professional surveyors as supervisors of measurers and recorders who worked with simple instruments that were sufficiently accurate over short distances.

In 1851 the Chief Engineer had to abandon an attempt to start a topographical survey of Gujarāt for lack of a qualified survey officer, and it was not until 1876 that serious attempts were made to produce topographical maps with the aid of the Gujarāt revenue surveys.

In Sind regular surveys had been started for irrigation purposes by William Baker in 1843 and, with scattered patches of revenue survey, were carried on later by Engineer officers burdened with other duties. The work was of little revenue value and was closed down early in 1850.

In 1855 request was made for the services of a professional survey party from the Punjab, and early in 1856 John Macdonald took down the party from the Bāri *doāb*, and started work in the Rohri collectorate of upper Sind. The Bombay Government agreed that the Bengal system should be followed and that work should be based on the Great Trigonometrical Survey. As Sind properties were mostly large estates or *jagīrs*, the main need was for a determination of areas, and a rough survey of the larger sub-divisions of each village.

As no boundaries had been marked out in advance, Macdonald spent his first season training the local *patwāris* and other recruits to survey by plahetable and chain. He found the boundary *thakbasts*, when they did arrive, reliable and complete, but had some difficulty in persuading the civil settlement staff of the advantages of the "Bengal system". As the survey advanced the party was split into two, one charge being allotted to William Lane, an experienced and capable assistant.

MADRAS

Though it was in Madras that the first systematic revenue surveys had been carried out—those of Alexander Read in Bāramahāl in 1793–8, and of Thomas Munro in the Ceded Districts during 1802–7—surveys that were the prototype of those in Bengal and Bombay—yet the Madras Government had never chosen to extend such surveys to other districts. They were content to leave district officers to continue the traditional unscientific methods of revenue assessment.

The first professional survey was that made by John Ouchterlony in the Nīlgiri Hills between 1844 and 1851. On the advice of the Surveyor General it was based on triangulation and followed the pattern of Wroughton's surveys of 1841–2 in south Mirzāpur and Sohāgpur. Detail survey on scale 1,000 feet to an inch distinguished ownership of lands, as between Government—private individuals—and the Todas, or aboriginal tribesmen. Small-scale topographical survey was later extended into outlying areas not covered by Ward's work of 1822. Ouchterlony's final reports and maps were submitted in 1852.

After much correspondence the Madras Government determined in 1855 that systematic surveys throughout the whole presidency were essential. On the strong recommendation of the Deputy Surveyor General they decided that survey should be based on the Great Trigonometrical Survey, without being a full topographical survey. Every field larger than about 10 acres in extent should be accurately surveyed, and a small survey establishment should be retained permanently in every village to maintain records. There was to be a military Superintendent of Survey of "scientific acquirements", with a number of deputies. Classification of lands should be left to the Civil Superintendent of Settlements.

In 1857 Captain Priestley of the 94th Highlanders, who since 1853 had been making a field-to-field survey in South Arcot, was appointed the first Superintendent of these Madras surveys. Large waste and hilly tracts were to be covered with topographical survey on the 4-inch scale, whilst culturable lands were surveyed on scales from 10 to 16 inches to a mile. It was estimated that there would

be just over 60,000 square miles for large scale revenue survey, and about 80,000 for small scale topographical survey.

Start was made in 1857 with only two parties, taking one *tāluk* (corresponding to a Bengal *pargana*) in South Arcot, and another in Trichinopoly. From 1858 survey was extended and the establishment steadily increased, whilst a lithographic press was installed at Madras for printing *tāluk* and village maps.

MAPS

Compilation, engraving, and publication of the quarter-inch Atlas of India were continued in London by the Company's Geographer, John Walker, and material was regularly sent to him from India. By 1860, however, the output of these sheets had fallen into arrears owing mainly to Walker's advanced age, and unwillingness to depute the work to others. As a result of the Surveyor General's continued protests, arrangements were at length made to transfer the production of these maps to India, and this was effected in 1869, when the sheets were broken down to quarter size on a modified projection.

The increasing demand for topographical maps was met by preparing one-inch and quarter-inch maps from the revenue surveys. The earlier issue of the quarter-inch maps for many areas had to be made without trigonometrical control, but from about 1845 the Deputy Surveyor General pushed forward their recompilation on proper geographical control, and had them printed at the local press.

From 1854 similar one-inch sheets for all the revenue surveys were sent to England to be lithographed, as facilities for such a large task were not available in Calcutta. Again there were constant complaints of delay, and this work was transferred to India from 1864.

For the fair mapping and reduction of the topographical surveys in the Himālaya, Kashmir, and Punjab areas the very best draughtsmen were employed. Drawn at Dehra Dūn, some of the maps were lithographed in Calcutta and others in London, and very beautiful maps they are.

About 1857 a start was made at Calcutta on the preparation of a general map of India on the 32-mile scale, one preliminary engraved sheet appearing in 1864 ; the first edition of the 64-mile map was dated 1868.

From about 1841 a section of the Government Lithographic Press at Calcutta had been set aside for the Surveyor General's demands but work was far from satisfactory. It was a great step forward when machines and staff were transferred effectively to the Surveyor General's office in 1852. New machines were constructed by the Mathematical Instrument Maker, and others purchased from England, and map printing thus brought under departmental control.

The first important task of the new office was the printing of the first postage stamps of India during 1854–5, pending supply from England. The stamps were designed and lithographed under the direction of Henry Thuillier, Deputy Surveyor General, and infinite trouble was experienced by staff that had no previous experience of such highly technical work, with presses and apparatus that required constant adjustments and modifications, and with materials that were not easily found. After 15 months a total of over 47 million stamps were struck off—Half-anna, blue—One-anna, red—Four-anna, red and blue.

Photo-lithography was started in Calcutta in 1862 in a very small way, and Hennessey inaugurated zincography at Dehra Dūn in 1866 after a course of training at the Ordnance Survey office at Southampton.

CONCLUSION

During his eighteen years in charge Waugh had practically completed the principal triangles of the Great Trigonometrical Survey over northern India. He

had worthily maintained the designs, principles, and procedure worked out by Everest, always insisting on the same high standards of precision. Of the new problems that he took up with eagerness and success were those of the heights of the great peaks—deflection of gravity—and spirit levelling.

There had been a continual passing of experienced officers and recruitment of replacements, and Waugh had constant anxiety in training and guiding the new staff, paying frequent visits to his field units, both in field and recess. The number of assistants was increased, and to maintain uniformity throughout the department he drew up full and detailed instructions on practically all professional subjects. Some of his new officers were men of high talent and full of ideas, but in weighing their suggestions Waugh was slow to admit innovations.

His most trusted assistants on the trigonometrical side were Renny-Tailyour, who joined with him in 1832 as Thomas Renny, and retired in 1854—George Logan, who joined in 1831, and at the time of his untimely death in 1854 was quite the most capable officer in the department—John Peyton, who had joined at Hyderābād in 1823, succeeded Joseph Olliver as Chief Civil Assistant, and retired in 1856. The Bengali computer, Radhanath Sickdhar, had a remarkable genius for geodetic computations; as Chief Computer he overhauled the computations of the field units and reduced them to final shape; his most notable work was the production of the first edition of the departmental geodetic tables. James Walker of the Bombay Engineers, was the most valued of the younger officers, and succeeded as Superintendent of the Trigonometrical Survey in 1861. Unlike Everest, Waugh took great interest in his topographical surveys and the resulting maps, and found high-class topographers in Montgomerie and Robinson.

He was content to leave full control of Revenue surveys and his Calcutta offices to Henry Thuillier, who was a tower of strength and an able administrator. The revenue surveys of Madras and Bombay did not come under his cantrol, but his parties spread from Assam to Sind under officers of the Bengal artillery and infantry, of whom Smyth, Sherwill, Gastrell, and the brothers Vanrenen were outstanding.

All three branches, trigonometrical, topographical, and revenue, were well served by their civil assistants and, in spite of competition with other departments which offered more attractive terms, the professional work of the survey attracted and held a number of devoted, capable men.

Of the design and choice of instruments, Waugh, like Everest, had his own ideas, and with the help of Saiad Mohsin Husain introduced several patterns of 24-inch and other large theodolites. As the Mir Sahib aged, and Waugh found less time for such details, he looked more to Alexander Strange, a Madras cavalry officer, with a flair for mechanics. Strange's alterations and devices were not always successful, and the great theodolite and the zenith sectors which he designed after his retirement proved too elaborate and cumbersome for field work in India. In his London office, however, as Inspector of Instruments, he effected a vast improvement in the quality of scientific instruments of all patterns sent out to India.

These eighteen years were a period of expansion and technical advance. Waugh was a man of wide interests and clear vision, who kept his department in step with the progress of professional thought and practice in the highest institutions.

The continued amalgamation of the two posts, Surveyor General and Superintendent of the Trigonometrical Survey, was under the circumstances undoubtedly wise, for the advancement of the triangulation grid was of primary importance, requiring the close direction of an officer of the highest talents. A second and senior officer would have had little to do except to waste money on unreliable surveys and maps and hamper his geodesist junior. The Court of Directors had not even accepted Everest's plea for a Deputy for each Presidency. Worthy topographical surveys were put in hand as and when the time was ripe.

CHAPTER II

NORTH-EAST QUADRILATERAL

MERIDIONAL SERIES ; *Karara, 1838–45 — Gurwāni, 1845–7 — Gora, 1843–7 — Hurilaong, 1848–52 — Chendwar, 1843–6 — North Maluncha, 1843–6 — Calcutta, 1843–8 — North Parasnāth, 1850–2* — NORTH-EAST LONGITUDINAL, *1846–51* ; *General — George Logan — Eastern Section — Sonakhoda Base — West Connection* — CONCLUSION.

THE North-East grid, or quadrilateral, of the Great Trigonometrical Survey was bounded on the west by the Great Arc, on the south by the Calcutta Longitudinal, on the north by the North-East Longitudinal, and on the far east by the Eastern Frontier series. To the ten subordinate meridional series between the Great Arc and Calcutta for which Everest had obtained sanction [IV, 12, 20] were added the Calcutta, and later the Brahmaputra, meridional series [pl. 4][1].

KARARA, 1838–45

When Waugh took over charge in December 1843 the Karara series, just west of Allahābād, was progressing slowly under Shortrede. This series had an unfortunate story. William Jones had selected five stations in south Rewah before the rains of 1838. When the whole party was overwhelmed by fever at the start of the following season, further work was abandoned until the end of 1841 when Shortrede was put in charge [IV, 68–70][2].

Though in many other ways an officer of considerable talent, Shortrede showed a singular lack of practical sense for conducting high-class triangulation [390–1]. He was ultra-cautious in facing the risks of jungle life, and hesitant in action. His triangles were laid out with little regard to the established principles of symmetry and in spite of repeated instructions from Everest he disregarded many of the essential principles of geodetic work [101]. During his two first seasons he established only ten hill stations and by the end of his third season had made so little progress that Waugh obtained orders for his return to Bombay. Shortrede handed over to his senior assistant, Armstrong, on 6th March 1845[3].

By this time the series had barely reached the Jumna from the south, but to hasten completion Du Vernet had been brought in to assist from the north during season 1844–5. With nothing prepared in advance, he completed 15 triangles by May 1845, extending about 90 miles south from his North Connecting series[4].

With equal determination Armstrong closed the gap of about fifty miles from Shortrede's work by 19th May, but he had then to go back to re-observe one of his triangles and observe a controlling azimuth. This was all satisfactorily completed by 13th July, when the two parties marched in to Dehra Dūn.

To gain some idea of the closing error, the Surveyor General himself visited the station of junction near Rae Bareli during September [IV, pl. 11 ; V, pl. 4] and "took a complete set of observations for azimuth". The discrepancies suggested that the southern portion was the more defective but, though "distressed by their magnitude", he did not think they warranted revision [132, 156][5].

[1] *GTS.* VII & VIII (frpoe), 1882. [2] *GTS. Syn.* XVI-M. [3] Assts. Armstrong, Kirwan, Hennessey. [4] Assts. James Mulheran, Glynn. [5] taking the circuit Karara—Gt. Arc—Conng. series, north & south ; DDn. 462 (21–51), 19–8–48, para 2 ; *GTS.* VII & *Syn.*, XVI (viii–M).

Several branches of secondary and minor triangulation were carried out by Mulheran and Glynn of Du Vernet's party to connect Allahābād, Lucknow, and other cities. Computations and reports were completed at Dehra Dūn during the rains of 1845, after which Du Vernet took up the Gurwāni Series, next to the east, and Hill took over Shortrede's old party to start the East Coast series[1].

GURWĀNI, 1845–7

In October 1845, Du Vernet started the Gurwāni series in Rewah, and worked north across the Kaimur Hills through Mirzāpur, Fyzābād, and Basti districts, a full distance of 211 miles [pls. 3, 4]. About 160 miles lay through the plains, crossing the Ganges, Gumti, and Gogra rivers, and requiring tower stations of average height about 25 feet. The rays between stations had to be laboriously traced and cleared. Positions of major towns were laid down by secondary triangles, and minor triangulation was run up the Ganges to Allahābād by Glynn during August 1846. The whole series was completed in two working seasons, observations during 1846–7 being carried out at 21 tower stations in a low, flat, and swampy country[2].

The Surveyor General visited the party at work in the field in February 1846, and warmly commended Du Vernet and his assistants for the work accomplished, which required "no ordinary degree of skill, judgement, and perseverance". His only complaint was that the hill-station platforms had no isolated pillars for the instrument [112][3]. Du Vernet lamented that on some of his ray-traces it took six days to traverse a distance of only twelve miles of "swamps, tanks, thick mango plantations, ... ponds, and minor obstacles".

Field work was closed by June 1847, when Du Vernet marched to Dehra Dūn to prepare for work on the North-West Himālaya series [34, 368–9].

GORA, 1843–7

The Gora and Chendwar series were taken up in 1843 out of their normal sequence because Government had thought it would save money to double the interval between the meridional series [IV, 21–2].

Leaving Dehra Dūn on 1st October 1843 in company with Renny and Logan, bound for the Maluncha and Chendwar series, W. N. James marched his party more than 500 miles to start the Gora series about 70 miles south of Chunār in the Mirzāpur district[4]. After marking out his triangles to about 60 miles, and observing at four stations, he was driven into quarters at Chunār by thick atmosphere, dust and smoke, and died there in June. His place was taken by Peter Garforth who had only recently joined the department.

During the following season, 1844–5, the party suffered severely from jungle fever, and only managed to select two principal stations, clear three rays, and build two towers and one platform. They spent the rains at Allahābād where the Surveyor General had fixed his own headquarters, and Garforth had the advantage of his close supervision and instruction[5], whilst the party was strengthened by the posting of Armstrong from the Karara series. Garforth was so anxious for a satisfactory outturn for season 1845–6 that he kept the field till 25th August, Armstrong and others having had to give up some weeks earlier [365–6, 457–8]. The towns of Chunār, Benares, Azamgarh, and Gorakhpur were fixed by ray-trace or minor triangles. The main series was brought to a satisfactory close before the rains of 1847, and Garforth resigned at the end of August.

[1] Report for 1844–5 ; DDn. 462 (69). [2] Assts, 1846–7, Mulheran, Glynn, Thos. Olliver, & Blewitt; *GTS.* VIII & *Syn.* XVII (N). [3] DDn. 492 (24–5), 14–2–46 ; 462 (21–51), 19–8–46. [4] Assts., Keelan, Thos. Olliver, & W. B. James; *GTS.* VIII & *Syn.* XVII (O). [5] DDn. 491 (247–60), 12–9–45 ; 462 (21–51), paras 21–30.

Armstrong now took over charge, and during season 1847–8 laid out of triangles along the Gora–Chendwar section of the North-East Longitudinal series [17; pl. 4].

HURILAONG, 1848–52

During his next season, 1848–9, Armstrong took up work on the Hurilaong series which runs northward from Lohardaga in Chota Nāgpur, through Arrah to Bettiah near the Nepāl border [pls. 3, 4][1]. To avoid the unhealthy season of the south he spent October 1848 on an extension of the triangulation which he had started two seasons earlier along the Ganges. Even with this postponement both of his assistants were seriously ill the greater part of the first season. Steady progress was, however, made on the main series during the next three seasons and junction with the North-East Longitudinal was completed by June 1852.

A considerable amount of secondary triangulation was carried out, mostly to survey the courses of the main rivers. During 1850–1 Armstrong carried the survey of the Ganges eastward to its junction with the Gogra, whilst Belletty surveyed 128 miles of the lower Son. During 1852–3 Belletty then surveyed the Gogra for a distance of 350 miles from its confluence with the Ganges, whilst Armstrong marched the party to the Punjab after the rains of 1852 [52, 185].

CHENDWAR, 1843–6

This was Logan's first independent charge and he carried it through without a hitch [IV, 380, 455][2]. Starting in December 1843 from Chendwar H.S. of the Calcutta Longitudinal series close to Hazaribāgh town, he selected, built, and observed at eleven principal stations by the 8th May, bringing two polygons and a quadrilateral up to the town of Bihār, a distance of ninety miles [pls. 3, 4]. He made recess quarters 1844 at Patna, 1845 at Monghyr, and 1846 at Digha Ghāt near Dinapore [336, 368][3].

Work continuing equally well the next two seasons, he crossed the Ganges just below Patna, and carried the series northwards through Muzzaffarpur to the Nepāl border, so that by 8th April 1846 he had completed the Chendwar series [17]. By the end of May he had not only laid out and constructed twelve tower stations on the longitudinal series to the west through the *tarai* forest at the foot of the hills, but had actually cleared the rays and observed all the angles, horizontal as well as vertical. On the Chendwar series he had worked with one of Troughton & Simms' 18-inch Theodolites, but for the longitudinal series he was given Barrow's Great 36-inch [148–9].

In these three seasons Logan had completed a continuous chain of no fewer than 42 triangles. The Surveyor General was greatly impressed;

> I had occasion last year to make highly favourable mention of this gentleman's progress, and it is very gratifying to me to be able again to bear testimony to the great success which continues to crown his zealous exertions. The quantity of work executed by him this season surpasses even his former efforts, and indeed exhibits the largest quantity of principal work ever yet laid out and finally completed in one season. ... All this work has been beautifully executed by Mr. Logan, who is a first-rate observer, and scrupulously careful in every part of his duty. ... His work is in every respect of a superior order[4].

NORTH MALUNCHA, 1843–6

The North Maluncha series ran northwards across the upland country of the Santāl Parganas to cross the Ganges near Bhāgalpur. In this hilly section it was

[1] Assts.; Terry, replaced by John Rossenrode 1849, Belletty and, from 1850, Paschaud; *GTS.* VIII & *Syn.* XVIII (A). [2] ib. (Q); Assts. Terry, John Rossenrode, Chas. Olliver: [3] on Ganges between Dinapore and Bankipore. [4] DDn. 462 (21–5), 19–S–46 (paras 32, 34); SG. to Mil. Dept.

laid out in the form of three polygons, but was continued across the plains to the north by short-sided single triangles [pl. 3].

Thomas Renny left Dehra Dūn in October 1843 with the original Budhon party which he had taken over in 1838 for work on the Great Arc [IV, 64]. On the march down country he was called away to military duty for three months and during his absence his senior assistant Richard Clarkson made a good start. After his return in March Renny carried the approximate series up to the Ganges. There was a good deal of sickness and five heliotrope men died during April [456]. On 1st June Renny handed over to Clarkson and went on furlough.

During season 1844–5 Clarkson, with but two assistants[1], observed two of the polygons south of the Ganges and cleared four rays to the north. In September 1845, with the warmest praise from the Surveyor General, he left for the Coast series after handing over to Reginald Walker. During season 1845–6 Walker completed lay-out and observation of the meridional series, and constructed towers for the longitudinal link with the series to the west. Work was far from easy, visibility was restricted, sickness rampant, and the heat intense ;

> The principle difficulties arose from the vast tracts of high grass jungle, ... it being quite impossible to troll a perambulator through it. ... I eventually was obliged to adopt a new method...of measuring short bases of about one tenth of a mile with the greatest accuracy at each station of the ray trace, and repeating the observations several times. By this means the various distances were obtained with considerable accuracy. ... Were it not for the increased labour...I should feel inclined to adopt it always in preference to the perambulator[2] [104]. ...
>
> Several of the best men...fell victims, ... causing great anxiety from the fear of a want of trained lampmen during the final observations. ... On the day when we first crossed the Donse River no less than twenty-two men fell ill, as also two of the sub-assistants [456]. ...
>
> The final observations were commenced...early in March, but the progress...was...very slow owing to...the very unfavourable state of the weather caused by high westerly winds raising dust from the extensive sands of the Ganges between Colgong and Monghyr, which at times so obscured the atmosphere as to render it impossible to distinguish objects even at the shortest distances. The heat during the months of March and April was very great, the thermometer standing at 110 degrees in the office tent for many weeks. ... A few breaks in the hot weather enabled me to get on by degrees. ... The bad weather lasted till the end of April when, easterly winds having begun, ... the weather became all that could be desired, and I was enabled to finish the observations at Pirdaori station...after getting only a few observations during the nine days that I was there[3]. ...
>
> The whole of the observations were by great exertions...completed in...June. The rains which set in with great violence at an unusually early period, ... the 13th of May, caused the rivers to swell...and so flooded the country that...I found it necessary to defer...minor triangulation...to the next season, and I marched into quarters for the rainy season[4].

The rains were spent at Darjeeling, and from October 1846 Walker worked on the longitudinal series eastward from the head of the Maluncha series [19].

CALCUTTA MERIDIONAL, 1843–8

The Calcutta Meridional series broke out from the base-line on the Barrackpore road [IV, 48–50]. It ran northwards, west of the Hooghly and Bhāgīrathi rivers, to within sight of Berhampore to strike the Ganges just west of Rāmpur Boālia, and it closed on the North-East Longitudinal near Titālya[5].

When Waugh took over as Surveyor General in December 1843 he handed over his party to Charles Lane in Calcutta[6]. Lane found the greatest difficulty in selecting stations, the country being congested with flourishing villages with two-storied houses, high and valuable fruit trees, and rich gardens. Owners strongly objected to damage or destruction, and the civil authorities would exercise no compulsion [477]. By the end of May nine polygons had been laid out

[1] Wm. Rossenrode & Webb ; *GTS.* VIII & *Syn.* XIX (S). [2] cf. modern subtense measts. with Hunter Short Base; *Geod. R.* VII, 1930–1 (63–5). [3] c. 18m. w. of Bhāgalpur. [4] DDn. 514 (299), 23–7–46. [5] *GTS.* VII & *Syn.* XX (iv–vii—1). [6] Asst.s., Lane, Nicolson, Nield.

to reach some 120 miles to the Ganges. To avoid the heavy line-clearing entailed by the polygons, Peyton who took over charge in October 1844 was directed to make a fresh lay-out of single triangles from the start. He was able to start building the towers, 31 to 44 feet high, during January and to commence observations by the middle of March. By the time rain stopped work about the 22nd May, he had completed observations for six triangles.

During the next three seasons he pushed the series northwards to its terminal stations near Titalya on the Darjeeling road[1]. The country was difficult and much time was spent in ray-tracing and selection of stations—clearing lines—building towers of mud bricks and sometimes rebuilding them—and finally the observations. Recess months were spent at Berhampore in 1844 and then at Chinsurah. During Lane's absence, 1846–8, the reconnaissance in advance was entrusted to Nicolson, who took over observation when Peyton was out of action; "while marching through a dense forest he was sprang upon and wounded by a leopard, which confined him to his bed for nearly a month [467]".

There was much sickness during season 1847–8, but Lane rejoined after assisting at the Sonakhoda base-line, and with his assistance Peyton completed the last observations by 9th May 1848, and then marched to recess quarters at Benares. The party then took up a section of the North-East Longitudinal [19, 361][2].

In February 1845 Nicolson was deputed to run a chain of secondary triangles down the Hooghly. He completed about fifty miles above Calcutta his first season, and during 1845–6 carried it down to the mouth of the river. He fixed semaphores and other navigation marks from 601 triangles and 195 other points by perambulator measurement. He writes to Peyton;

> We had awful work of it down the river, enough to sicken anybody. We[3] used to get every day well washed with salt water, but...managed to finish our work, and also got over the star observations at Diamond Harbour and Kaokhali lighthouse. At this latter place I could not, however, manage to get Ursa Minoris owing to thick vapour and clouds prevailing in consequence of the vicinity of the sea, although I remained there 20 days. ...
>
> I have been trying my hand at topographical work, and have been sketching the country along the banks of the river all the way from Kaokhali. For this purpose I was obliged to travel on foot in this dreadful weather 9 or 10 miles every day[4].

Eighteen months later a copy of Nicolson's map was required for "planning an electric telegraph from Calcutta to the sea"[5]. His chart, with the addition of Sāgar Island and lighthouse, fixed later by Bedford the river surveyor, was lithographed in 1856 and expected to be "very useful to the Marine Department as a skeleton on which the shoals can be periodically inserted"[6].

NORTH PARASNĀTH, 1850–2

This was the last of the meridional series to be taken up, and falling between the Chendwar and Maluncha ran north from Parasnāth Hill through the districts of Monghyr and Darbhanga [pls. 3, 4]. It was carried out during seasons 1850 to 1852 by the party from the Calcutta Meridional under charge of Nicolson [361][7]. Across the uplands south of the Ganges it was laid out in large triangles of 20-mile sides, but sides were limited to 10 miles across the plains to the north.

The younger Dunlop, James, had trouble with one of the party elephants[8];

> The country in which his work lay being very wild and devoid of roads, I sent one of the government elephants...with him. Whilst at Donari Ghati on the morning of the 27th at about 2 o'clock, the attendants being still asleep, the elephant broke her...wooden ring with which she was secured to a peg, and escaped into the dense forest under Parasnath mountain.
>
> At about 3 a.m., the animal being missed, Mr. Dunlop gave immediate notice to the police, and also sent out all the men he had with him in search of her. Subsequently...I deputed the

[1] now joined by John Dunlop & John James. [2] *GTS.* VIII & *Syn.* XIX (B). [3] with John Dunlop. [4] DDn. 514 (125), 1–10–46; 1-inch maps; *IO Cat.* (40); MRIO., 166 (2, 3); ½-inch, Misc., 1–0–47. [5] DDn. 493 (7), SG. to Peyton, 20–1–48. [6] DDn. 662 (261), DSG. to SG. 24–9–56. [7] assts., John & James Dunlop and Berrill. [8] when fixing position of Kherabari coal-mines.

jemadar...with some men...and the other two government elephants to endeavour to recapture the animal, which by this time was traced through the jungle to a place 30 miles east of Domri. ... The party traced her by footprints for about 60 miles, but unfortunately came upon her but once, and then owing to her having become very wild and fierce she could not be approached, even with the aid of elephants. The men were obliged to give up their pursuit and return, having all been attacked with fever.

Work was hampered by thick haze and smoke, and at the end of March 1851 the party was overwhelmed by fever ; Nicholson had hoped that

leaving the unhealthy tract...the sickness in camp would have abated, and that I would still be able to close the final operations for the season beyond the Ganges river. But in this I was greatly disappointed. The sickness increased daily, so that on the 5th...there were only 5 khalasis, the jemadar, and 2 barkandazes on the effective list. The native doctor was also so very helpless from fever that he could render no medical aid to the sick [461]. ...

I considered it advisable to leave the place and proceed to Surajgarh which, being on the Ganges River was considered a likely place for recruiting the health of the men. While on the march both Messrs. Berrill and Dunlop were so seriously taken ill that I was compelled to halt a couple of days at Buntad Rampur factory.

On the 11th we arrived at Surajgarh and on the following day Messrs. Berrill and Dunlop were sent down to Monghyr for medical aid and on the 13th, finding myself also very ill, I left the place for Monghyr. On the 14th and 15th all the sick amounting to 45 in number arrived by boats at Monghyr and were sent into the hospital where four of them died shortly after. About this time 3 others who did not attend the hospital were carried off by cholera[1].

John Dunlop had been selecting stations in advance, and he also came into Monghyr sick, and died there "after a long and painful illness".

The series was completed during season 1851–2, during which Monghyr was connected by secondary triangles, and the Ganges surveyed for a distance of seventy miles. Nicolson then took up the Assam Longitudinal series [29].

NORTH-EAST LONGITUDINAL, 1846–51

The North-East longitudinal series extends eastward from the Great Arc to the Calcutta Meridional a distance of about 750 miles, and connects the Dehra Dūn and Sonakhoda base-lines and the heads of the meridional chains. Except for the few western stations falling in the lower hills of Garhwāl and Kumaun, the series runs wholly in the plains through the fringes of the unhealthy *tarai* belt just outside the Nepāl border. Permission could not be obtained for the surveyors to enter Nepāl territory [85];

Had the triangulation been carried over the hills the lengths of the sides might have been materially increased, and the number of stations correspondingly diminished. The heavy cost of building towers at each of the stations in the plains and clearing the lines between them would have been avoided, and serious mortality...might have been prevented[2].

This long series was not executed as one continuous project but, as first suggested by Everest, the surveyor of each meridional series was to connect the head of his own series with that to the west [IV, 18–20]. The connection between the Great Arc and the first three series, Budhon, Ranghir, and Amua, had been carried out before 1844 by Du Vernet and Waugh [IV, 67–8, 71], and continued by Du Vernet through the plains to the head of the Karara series [IV, 71 ; V, 18]. This earlier work was superseded later when better instruments became available, capable of giving results worthy of its geodetic importance [21, 153].

The whole series comprised 111 stations, mostly towers of mud or sun-dried brick with a central isolated pillar of masonry, arranged in 135 single triangles with sides averaging about 11 miles in length. It was carried out in five sections [2];

From the Great Arc near Hardwār to the Ranghir meridional series near Pilibhit —17 triangles by Renny and Peyton, 1849–50, with Waugh's 24-inch theodolite.

From the Ranghir meridional to the Chendwar series north of Muzaffarpur— 74 triangles, by Logan, seasons 1845–7 and again from 1848–50, with Barrow's 36-inch theodolite.

[1] DDn. 602 (64); Nicolson to SG., 1-5-51. [2] *GTS.* VII & *Syn.* XXXV (iii—1).

From the Chendwar meridional to the Maluncha series on the Kosi River—16 triangles, by Peyton, 1848–9, with Barrow's 24-inch theodolite No. 2.

From the Maluncha meridional to just short of the Sonakhoda base-line—19 triangles, by Reginald Walker, 1845–7, with Cary's 15-inch and Troughton & Simms' 3-foot.

Nine triangles covering the Sonakhoda base-line on the Māhānanda River—by Charles Lane, 1847–8 with T. & S. 3-foot.

Start was made at two points in October 1845, Logan westward from the Chendwar series, and Walker eastward from the Maluncha.

N.E. LONGITUDINAL; GEORGE LOGAN

During season 1845–6 Logan selected the last three stations of his Chendwar series and fourteen of the longitudinal series, working westward towards the Gandak River[1]. He erected towers from 25 to 35 feet high—cleared the jungle along connecting rays—completed all observations, horizontal and vertical, and observed the usual azimuth at one of the junction stations.

After spending the recess months at Digha Ghāt [13 n.] he resumed in October 1846, only to be held up by virulent malaria, the penalty for too early a start in the *tarai* forests. Two-thirds of the followers had to be carried into Gorakhpur where about 35 of them died.

Work was resumed at the end of December, but the heavy rain of January destroyed large quantities of the sun-dried bricks that had been prepared for the towers. Nine towers were, however, built, lines cleared, and observations completed to a point just south of Tribeni where the Gandak breaks out of the mountains. Work was closed down in March 1847 and later that year after recessing at Digha Ghāt the party was diverted to assist at the measurement of the Sonakhoda base-line, and did not resume triangulation till October 1848.

During Logan's absence Armstrong carried on the approximate series with the party from the Gora series [13].

> The locality from which Mr. Armstrong was to commence being unhealthy before 15th December, ... I directed his attention during the months of October and November to the interesting duty of laying down the positions and determining the heights of the principal Himalayan peaks north of Nepal [82][2].

Armstrong laid out 16 stations between the Gandak and Gogra rivers, constructed the towers, cleared the rays, and with his 15-inch theodolite took observations to a number of snow peaks between 10th November and 26th December 1847, one of these being his "peak b", interesected by two rays with one vertical angle, the first observations to the peak that is now known as Mount Everest. His theodolite was not, however, considered adequate for the principal angles of so important a series, nor were his observations to all the peaks accepted for final computations [91, 156]. He writes to Logan in March 1848;

> I feel indeed very much the want of an assistant as Mr. Terry is exclusively employed in tower-building (of which he has now nine on hand) and I have no one to assist me in triangulating and clearing rays though...I...have fortunately proceeded thus far with more success than I could have possibly dreamt of.
>
> But it has been really a harrassing work, ... and I am afraid I wont be able to hold out beyond April under the racking fatigues of field work from sunrise to sunset, and office duties some portion of the night. Success hitherto has smiled upon me and buoyed up my spirits, though cheerless the task is when there is not a companion by, with whom to exchange a passing thought or repartee [410]. ...
>
> I shall be able to select two more stations before the close of this month and have 4 or 5 left to reach the head of the Gurwani series[3]. If even all these stations are selected and rays cleared I fear much that the towers will scarcely be built unless I discontinue my further progress and undertake...a few myself.

[1] Assts., Keelan, John Rossenrode, & Hennessey. [2] DDn. 462 (265–307), SG. to Mil. Dept., 15 1–49. [3] north of Fyzābād.

Mr. Terry has already a number to look after and if masons were only easily procurable in these parts he would finish those on hand quick enough and take up others in succession, but he is much cramped in this respect, as well as in procuring brick-makers. ... We will, however, do better as we proceed out of these horrid jungles. ...

I have directed Mr. Terry to observe approximate angles at each of the towers as it is finished to determine the nature...of the rays. ... The heights...give sufficient scope for a clear view of the heliotrope and I dont think that any impediments need be apprehended[1].

He reports to the Surveyor General two weeks later that,

from the 4th January when the operations were first started up to the 26th March when Bankatta station was fixed upon, ... no less than 17 rays have been cleared, ... four of which were through heavy forest and eight partially so ; ... five days only to a ray. ... To make the connection symmetrical with the Gurwani series I purpose proceeding shortly to the head of that meridian with an approximate survey to determine the position of Captain Du Vernet's points.

He tells Logan at the end of May that he was preparing to close work and march to Allahābād ;

At Ganeshpoor and Majhaowa arrangements were...made for raising the buildings this season. At the former station about 30,000 bricks have been made while at the latter about as many more, but...progress has been so slow from want of labourers that I have been compelled to order the stoppage of further labour and to burn such as are ready before leaving. ... The country hereabouts appears to be panic-stricken by the ravages of the cholera. ... From two or three casualties...the dread has spread abroad and my men...scarcely ...make even a thousand a day.

Cholera has been busy also in my camp but...only one case proved fatal, and that was the havildar of my escort, who was taken away in less than 12 hours. There was a case...about a couple of days ago, but the man has recovered and is now doing well[2].

Between 2nd January and 20th of May he had extended Logan's series by 16 stations selected, 32 rays cleared, and 12 towers built. He had fixed the positions of 104 villages by perambulator, and 31 villages and temples by intersection. In October 1848 he moved his party to the Hurilaong series [13].

Logan started season 1848–9 by rebuilding the summits of all Du Vernet's towers to adapt them for the great 36-inch theodolite. He then marched eastward to complete and check up on Armstrong's approximate series. To take advantage of the clear atmosphere of November he set up his theodolite at once over the ground marks of such towers as had yet to be built and

was also fortunate enough to obtain observations to the snowy range at several of the principal stations, and succeeded in determining by symmetrical triangles the height and position of every prominent peak between the meridians of Hurilaong and Karara [84 ; pl. 3][3].

By the end of season 1848–9 he had completed observations at all Armstrong's stations, and brought his work up to Bahraich, just east of the Karara series and, writes the Surveyor General,

as the party had suffered much in health, I ordered it up to...Masuri for the recess. Mr. Logan and all his party were much reinvigorated in health during this sojourn, and left me on the 20th October to return to the terai.

After completing the gap, ... Mr. Logan was instructed to employ the small remaining portion of the season in revising Captain Du Vernet's part of the frontier esries which had been executed with an inferior instrument and exhibited wide discordances [IV, 71 ; V, 16][4]. The large theodolite was put up at the station of Dadaora on the 7th December, between which day and the 4th April final angles were completed at 27 stations, a splendid season's work by which the gap was completely filled up. ...

Owing to the arrangements which had been made, the party entirely escaped...the malignant jungle fever from which it had suffered so severely during the two former seasons[5].

In the course of five seasons from 1845 to 1850, during which one season was devoted to Armstrong's approximate work, Logan's section had been carried from the Chendwar series on the meridian of Patna to Waugh's connecting series through Pilibhīt, whilst several minor series had been carried out by his assistants. The party was now moved to the Punjab to take over from Du Vernet the principal triangles of the North-West Himālaya series [36, 361, 393].

[1] DDn. 504 (134), 19-3-48. [2] ib. (140), 21–5–48. [3] DDn. 502 (80), Report for Nov. 1848; 30-11-48. [4] Mohsin Husain's 18° [156]. [5] DDn. 593 (131), SG. to Mil. Dept., 25-7-50.

Just as Logan swung his Chendwar party westward into the longitudinal series during season 1845–6, so also did Walker swing the Maluncha party to the west, but without taking any observations other than those of the polygon at the head of the Maluncha series that was to form part of the longitudinal series.

In October 1846 he started the extension towards the east through wooded country that still lay under flood-water as late as December. January 1847 was devoted to selecting a site for the Sonakhoda base-line which was to form one of the interior sides of the Rāmganj polygon at the head of the Calcutta meridional. The party now being joined by Lane, Walker started observations from the Maluncha end[1], but had only completed nine triangles when he collapsed with fever and had to be carried to Darjeeling. On arrival there he was found to have died in the *dhoolie*, unknown to the bearers[2].

Lane took over charge and joined the Surveyor General in Sikkim on secondary triangulation for the fixing of positions and heights of Himālayan peaks [83].

Rossenrode, who had been working on minor triangulation to fix the Nepāl boundary pillars, took over construction of towers and pillars of the base-line polygon. The angles of this Rāmganj polygon were observed by Lane after measurement of the base-line, but were re-observed by Nicolson in 1855, owing to discrepancies attributed to deflection of the towers[3] [*inf.*, 30, 106–9].

The Maluncha party was now taken over by Renny and moved to Central India to take up the Great Longitudinal [37, 361].

To complete the gap now left between the Chendwar and Maluncha series, the Surveyor General brought up Peyton and his party from the Calcutta Meridional during 1848 [15]. Peyton completed these 16 triangles between Muzaffarpur and the Kosi by May 1849, but had little success with the snow peaks [85]. He then handed over to Nicolson, and joined the headquarters office at Dehra Dūn, to assist Renny-Tailyour[4] with computations and re-observation of the triangles of Du Vernet and Waugh to the west [21].

Nicolson had been employed on minor triangulation to provide points for the revenue surveyors [119, 295–6]. After taking over charge he spent the first three months of season 1849–50 revisiting Peyton's stations to observe the snow peaks[5]. Being free to devote his whole attention to the peaks he was able to take full advantage of three spells of clear visibility—a few days in early November—two weeks from 27th—and one week in January. It was mainly from these observations that the position and height of Mount Everest was eventually deduced [85, 92].

He then re-observed the double polygon at the head of the Maluncha series and, after minor triangulation to various places in Purnea District, withdrew to Monghyr for the rains. This re-observation confirmed the Surveyor General's suspicion of the stability of the towers ;

> Your revision of the double hexagon at the north extremity of the Malunch series increases the error, which is perhaps attributable to the towers having deflected. ... The...error of your double hexagon is precisely the same as the error in Lieut. Walker's observations with the old 15-inch theodolite by Cary [156], but your angles differ widely from his [*sup*][6].

In October 1850 Nicolson took up work on the Parasnāth series [15–6].

SONAKHODA BASE

To balance the base-lines at Calcutta, Sironj, and Dehra Dūn, the Surveyor General decided to measure a fourth at the junction of the Calcutta Meridional with the North-East Longitudinal series, and in January 1847 inspected a site at Sonakhoda below the Darjeeling hill that had been selected by Walker. He saw the line marked out on the ground ;

[1] with 15-inch Cary ; assts., Lane, Wm. Rossenrode, Webb, Lawrence. [2] cf. Voysey [III, 510].
[3] *GTS.* II & *Syn.* XXXV (ix-1). [4] Thos. Renny added name—Tailyour—from Nov. 1849 [379].
[5] with John Dunlop [419]. [6] DDn. 515 (226), 2-7-50.

The towers at the ends of the base should be constructed early this season, so that they may settle down into a permanent position before the measurement commences. There will be two marks in the basement of each tower, and these ought to be very carefully adjusted over each other. ... I hope...that Mr. W. Rossenrode to whom you propose entrusting the building will exert his well-known skill to produce towers worthy of the occasion.

The towers were to be of burnt brick, pointed with lime mortar, of height 22 feet including plinth. There was to be a *pucka* stairway for raising the instrument, and an arched entrance to an inner vaulted chamber protecting the lower mark-stone [106–7][1]. The project was explained to Government ;

The Great Arc and the Calcutta Longitudinal series have already been accurately tested by the base-lines measured on the Barrackpore road in 1831, in the valley of Dehra in 1835, and in the valley of Sironj in 1837. Consequently there now remains a single base-line to be measured at the north-east angle of the quadrilateral...whereby...all the intermediate triangulation will be duly tested and reduced to order.

This base will at the same time furnish a proper point of departure for the future extension of the longitudinal series to the eastward through Assam, ... and fixed points will be furnished for incorporating the revenue surveys of the intermediate districts [295–6]. ...

A line 7 miles long has been chosen which possesses all the requisite conditions for ensuring accuracy, viz., an extremely level and unbroken surface to measure over, and a position so situated with respect to the circumadjacent stations as to form symmetrical triangles therewith. ... The alignment and smoothing of the ground, its division into sections for verification by minor triangulation, and the construction of suitable marks to define the limits...will occupy considerable time. ...

I propose early next season to unite Lieut. Walker's and Mr. Logan's parties, which...will furnish nearly a sufficient complement of men for the purpose. Mr. Logan himself has been employed at the measurement of four base-lines and two of his sub-assistants have also had the advantage of previous experience [43][2].

The base-line apparatus has not been in use since 1840–41, at which time I was deputed to measure therewith the base...north of Bedar. It requires to be put in thorough order, ... for which purpose...the instrument-maker Syad Mohsin, should proceed to Dinapore, where I have fixed my depot at present. ... The Indian standards of measure and temperature are at present deposited in my office at Calcutta, and can most conveniently be brought up country under the care of Syad Mohsin[3].

After Walker's tragic death, Rossenrode was made responsible for all preparations at the site, whilst the Surveyor General took Lane and the rest of the party up to Darjeeling for observations to the snow peaks [83]. At the close of the rains Logan arrived with the base-line apparatus, and was joined at Sonakhoda by Lane's Maluncha party. Thomas Renny cut short his furlough to complete a strong team for the measurement[4].

Logan...was engaged with the Mathematical Instrument Maker...at Dinapore in putting the base-line apparatus in order, and training some of the sub-assistants to be employed in the measurement. He commenced his journey on the 16th October 1847, and after a very anxious and harassing march over bad roads, he arrived at the base-line on the 9th November. ...

Captain Renny, who had returned from England at an earlier period than he otherwise would have done in order to be present at the measurement, joined me at Darjeeling on the 1st November, and the whole party was congregated at the base-line by the 22nd. ...

The field work of the measurement occupied the whole period of daylight from sunrise to sunset, with exception of 2 hours in the middle of the day, required by the native establishment for their meals. In addition...I had the current business of my office and medical duties of the camp to attend to, which were the more onerous on account of the number of cases of jungle fever [457]. ... I was generally active and continuously engaged from daybreak to near 12 o'clock at night. ...

The compensation bars were compared 53 times at the middle, and 80 times after the measurement [IV, 47]. ... After two days...drill the measurement was commenced on the 4th December and brought to a successful conclusion on the 21st January[5].

The minor triangles of check and the principal triangles of the Rāmganj hexagon were then observed by Lane [19][6] and later reobserved by Nicolson [19, 30].

[1] DDn. 492 (10–3), SG. to Walker, 6–2–47. [2] Keelan & Thos. Olliver [IV, 53 n.2 55n. 4]. [3] DDn. 462 (114–7), SG. to Mil. Dept., 18–2–47. [4] Waugh, Renny, Logan, Lane, Keelan, Thos. Olliver, John Rossenrode, Hennessey, John James, Lawrence, Haycock, Lawler, Mohsin Husain. [5] DDn. 462 (265–307), SG. to Mil. Dept. 15–1–49 ; site, 26° 17′ N. ; 88° 17′ E. ; length 6·95 miles. [6] *GTS.* 1 ; V (2–31).

There still remained the revision of the triangles between Dehra Dūn and Pīlibhīt that had been observed by Du Vernet and Waugh between 1841 and 1844 with smaller instruments [IV, 71, 473][1], and this was entrusted to Renny-Tailyour and Peyton during season 1850–1. Whilst Peyton modified the tower stations in the plains to take the 24-inch theodolite, Renny-Tailyour started from Banog and observed at several stations before handing over to Peyton in February [63];

I only commenced taking the angles at Banog H.S. on the 23rd October[2]. From Banog I proceeded regularly from station to station until I reached Dhela H.S. [IV, pl. 4] on the 10th January, when heavy snow fell on the mountains and interrupted the observations. ... In the course of 5 or 6 days the lampmen managed to shew their signals, ... but Saunchalia being full a thousand feet higher, or upwards of 8,500 feet above the...sea, all access to it was cut off for nearly a month.

I had previously caused huts to be constructed, and wood stored at all these stations, and I had ordered the lampmen always to keep a month's supply of food by them. ... The men at Ghungti...had been provident, ... and the road to the station had not been much impeded by snow, but at Saunchalia the snow had fallen very deep, and two of the lampmen had been snowed up for 4 days with scarcely any food, and were only rescued by the energy of the messengers I sent. ... I had posted 4 men at Saunchalia but the day before the snow fell two of them came down the hill to buy food for the party and were afraid to go up again until my messengers arrived, and the men on the hill...were afraid or unable to venture down through the deep snow after making an unsuccessful attempt.

Having taken all the angles at Dhela except those in connection with Saunchalia, I marched to Bagwara Tower Station to assist Mr. Peyton in completing the towers[3]. On the 9th February I made over charge to Mr. Peyton, and he took the remainder of the observations, visiting all the tower stations first, and ending with the hill stations of Birond, Saunchalia, Dhela [IV, pl. 4 ; V, 63, pl. 3][4].

CONCLUSION

Although the North-East Quadrilateral was the first figure of the Great Trigonometrical Survey to be completed, yet the final reduction was left till last, for this had to wait for the revision of the Calcutta Longitudinal observations and the adjustment of that series as part of the South-East Quadrilateral [129]. It was then recorded of the North-East Longitudinal series that it contained "some of the best work of the Indian triangulation. ... Mr. Logan's work of 27 triangles with an average triangular error of 0·28 in season 1849–50 being a very notable performance"[5].

The same could not be said of the meridional series. Waugh's preliminary reduction showed that there were many errors to be distributed, and several of the subordinate series came under suspicion. The instruments used on them had not all been of the best, and some of them, especially Karara, had been much interrupted and burdened by faulty work. The main defect, however, of this north-eastern grid was the weakness of the Calcutta Longitudinal series, and this was entirely re-observed between 1863 and 1868 [128–9]. In the latest classification these ten subordinate series have all been classified as of secondary order.

At the time of the measurement of the Sonakhoda base, its height above the sea-level was deduced by barometer, and this was later adjusted to the value brought up by triangulation through the Calcutta Meridional series. This value was subsequently corrected by a matter of just over two feet after levels had been run during 1848 by Hill from the Kidderpore tide-guage to the base-line towers on the Barrackpore road [71]. The heights then accepted by the Surveyor General for the two ends of the Sonakhoda base were 215·3 and 237·7 feet respectively, and these values were used in computing the NE. Longitudinal series and the snow peaks, and gave the height of Banog 7454 feet[6] [66].

[1] TS. 9/1, 4. [2] with Peyton, Blewitt, Haycock ; v. DDn. 455 (129–30), 9–12–50. [3] height from 10 to 38 ft., four being perforated. Saunchalia, Kumaun, 8,497 ft. ; *GTS.* VII, & *Syn.* XXXV (XII–1). [4] DDn. 569 (8) or 153 (60), Report 1850–1, Renny to SG. 10–6–53. [5] *GTS. Syn.* XXXV (XIV–1) ; Markham (104–5). [6] Latest value from spirit levelling 7429·233, lower mark.

CHAPTER III

EAST COAST & ASSAM

South Maluncha Series, 1845–7 — COAST SERIES ; *Hill & Clarkson, 1847–52— Peyton 1852–5 — Strange & Basevi, 1856–61* — ASSAM LONGITUDINAL : *Du Vernet, 1853 — Nicolson, 1853–6 — Lane, 1857–9 — Eastern Frontier, 1859–61.*

IN 1844 the Court of Directors called for triangulation to be carried through Orissa so that the areas already covered by revenue surveys and remaining for topographical survey could be made available for the Atlas of India, and extended to link up with the surveys already carried out in Ganjam. They further suggested that the services of Thorold Hill would be of particular value from his local knowledge of Goomsur [IV, 253–5].

The Surveyor General thought that the Calcutta Longitudinal was of too poor a quality to serve as the basis of such an important series, which he recommended should start from the Calcutta base-line and follow

the line of the sea-coast...through Midnapore and Cuttack until it forms a union with the terminus of the Parasnath series [IV, 59–61]. From thence continuing along the coast it would combine with the late Lieutenant Buxton's operations, and proceeding by Jagannath it would finally connect with the operations in Ganjam [III, 18–9 ; IV, 253]. ...

Moreover, as...uniformity of system is indispensable to complete success, I would strongly urge...the benefits which would accrue from Captain Hill being ordered to join the G.T. Survey in Bengal for a season[1].

Hill was accordingly posted to the Great Trigonometrical Survey on 31st January 1845, and joined the Surveyor General's field headquarters at Allahābād for introduction to geodetic work. From 1st September he was posted to charge of the party recently employed on the Karara series, the designation of which was now changed to that of Coast Series [12, 361][2].

As the best instrument available was an 18-inch theodolite that was hardly good enough for such an important work [156], the Surveyor General decided that pending the arrival of the new 24-inch theodolites Hill should use this smaller instrument on a less important subordinate series ;

I am very sensible of the great advantage that would be secured by making your triangulation originate at the Barrackpore base-line, whereby your operations would be rendered independent of the Calcutta Longitudinal series, and thus be entirely freed from the discrepancies inherent in that work. But, on the other hand, must be considered the difficulties and expense which attend trigonometrical operations in a flat wooded country...between Calcutta and Midnapore. ... Your work should, in the first instance at least, emanate from the most eastern hill stations of the Calcutta Longitudinal series. ...

Hereafter...your operations can readily be united with the Barrackpore base-line by means of a direct series passing through the Midnapore district, and the experience which you will... have gained of trigonometrical operations in general, and the nature of the country in particular, will enable you to form such a junction much more advantageously. ...

You will, therefore, proceed in the first instance to take up the side Susinia to Karasoli of the Calcutta Longitudinal series[3] and carry your triangulation southward along the meridian of Maluncha until you reach the coast. From thence your operations will tend to the south-west, ... in the direction of Cuttack [pl. 3].

Your principal series should be composed of a succession of quadrilaterals or...polygons... but, if...the country should in some places oppose invincible obstacles to...a double series, it will be better to revert for a time to a single one...than to delay the work.

[1] DDn. 506 (119), SG. to Mil. Dept., 17–12–44. [2] DDn. 455 (42–3), DO., 4–8–45 ; *GTS. Syn.*, XIII A (ix–xii); Assts., Clarkson, Kirwan, W. E. N. James, Lawrence. [3] between Purulia and Asansol.

After reaching the neighbourhood of Midnapore, it will be necessary to make arrangements for filling up the details of the country. ... As it is...laid down by the...Directors that no district which has once been surveyed in detail shall be resurveyed until all blank spaces are filled up, I have directed the Deputy Surveyor General to furnish for your guidance a map of the Revenue Surveys. ... These it will be your special duty to connect, with the view of furnishing the means for combining and adjusting [296]. ...

The Parasnath Meridional series, ... which is situated about a degree west of the Maluncha meridian, has been carried as far south as latitude 21° 28′ 26″, where it unites with the triangulation...by Lieutenant Buxton. ... These...it will be your duty...to connect with your own triangulation [22]. ... As soon as you reach the coast it will be desirable to embrace the...opportunity of verifying the heights...by reference to the direct level of the sea[1] [25–6, 71].

Hill marched out from Allahābād on 6th October 1845 with Clarkson as senior assistant [12, 409], and by the end of June had carried an approximate series southward from Asansol, and observed at six stations ;

The route from Allahabad to Raniganj colliery on the Damudar River was surveyed [184–5]. ... Observations for azimuth were taken [131–2]. ... The season proved particularly unfavourable for the final observations ; after being encamped at Sussinia hill for upwards of a fortnight in the month of March, I left it without obtaining an observation, and proceeded to the southern stations where, the sides of the triangles being shorter, it was hoped that the heliotropes or lamps might be visible.

The whole month of April proved equally thick and hazy, and on the 1st May the angles of one station only had been completely taken, and partly so at a second station. Rain falling early in May cleared the atmosphere, and during that month the final angles were observed at four stations. It was not until June, after the rains had set in that the final angles at Sussinia and Tilabani could be obtained[2].

By the middle of February 1840–7, he had completed observations north of Midnapore and then, leaving those to the south for a future opportunity, switched his party to Calcutta to start on the Coast series. The country on the Maluncha line had been far from favourable ;

For miles on either side of it is one vast forest, principally heavy tree (sal) jungles, and in the lower and cultivated parts so thickly wooded with large timber of mango, pepul, mawa, tamarind, blackwood[3], etc., that it is more difficult and more expensive to clear a ray there than in the jungle itself. ... There are no hills or prominent eminences, but a continued succession of gentle undulations which deceive the eye...and, all being covered with forest, it became a matter of great difficulty to ascertain which were really the highest spots [467–8]. ...

The towers at Gap and Kukurinuni are round and built of sun-dried bricks, but experience has shewn me that there are great objections to this style of tower in the moist climate of Bengal, and I adopted a different plan...at Kolapani and Kalsilebanga where, timber being available for the expense of cutting it, I erected solid pillars with a broad base—something resembling an obelisk in shape—and built scaffoldings round them for the observatory tent. These pillars and scaffolds were erected at a trifling expense, about Rs. 50 each, and I found them steady and to answer the purpose in every respect [108][4].

The remaining stations of the Maluncha series to the south were selected by Hill during season 1849–50, but the building of the towers and observation of angles had to wait till Peyton completed them in season 1852–3 [26]. Owing to the inferior power of Hill's theodolite the results of the South Maluncha, as well as those of the South Parasnāth, were excluded from the final reduction [129][5].

COAST SERIES: HILL & CLARKSON, 1847–52

Starting in February 1847 Hill found the break-out of the Coast series

a somewhat perplexing undertaking for, the base-line being situated on the north side of Calcutta, it was no easy matter to start the series symmetrically. ... To pass directly over the city would require a commanding station.

Permission was obtained to establish such a station on the dome of La Martinière College, which gave a fine view and formed a convenient point of the polygon

[1] DDn. 506 (95), SG. to Hill, 1–9–45. [2] DDn. 507 (7), Hill to SG., 25–7–46. [3] *mangifera indica* ; *ficus religiosa* ; mohwa = *bassia latifolia* ; *tamarindus occidentalis* ; blackwood = *dalbergia latifolia*. [4] DDn. 508 (182), 20–7–47. [5] *GTS. Syn.*, xiii.A (vii–ix).

connecting the three lines of triangulation—the Calcutta Longitudinal—and Meridional—and the Coast Series[1].

Two old telegraph towers were adapted and new towers built [108];

Although the towers...are from 80 to 90 feet in height, they were not found to be mutually visible until the rays between them were cleared, and so thick is the forest of fruit trees... that on the ray Nibria to Dilakoss it...was...necessary to fell 248 of various kinds, the greater number of which were cocoanut trees, a laborious undertaking, and attended with considerable expenditure of money[2] [477].

In November 1847, after spending the rains again at Midnapore, Hill moved in to Calcutta to look to the platform and staircase on the Martinière dome, which were ready for him the following month when he took a series of observations to determine the error of the 18-inch theodolite. Three months later he received one of the new 24-inch theodolites by Troughton & Simms [148, 153], and took a similar set of angles for comparison. Alterations had now to be made to all the towers to admit the new theodolite, James being detached with carpenters and brick layers for the purpose.

Considerable delay in the final work occurred at the base-line towers, first from Hill's illness, and then from hazy and cloudy weather preventing the heliotropes being seen at the time of minimum refraction.

There were continual difficulties—the clearing of rays—disputes over compensation—transport of materials, baggage, and the great theodolite—violent storms in the spring—cost of timber and bricks, the latter being cheap at Rs. 2/8 a thousand. The ray La Martinière-Samalia passed over the gardens and buildings of Alipore, and the Samalia tower had to be raised an extra three feet, which with the lopping of a few branches gave the visibility required.

The movement of camp across the country...was...not wholly devoid of danger. The transport of the 24-inch theodolite over rapid streams when only crazy boats were procurable... gave cause to considerable anxiety. When the party were encamped at Banibon the bursting of a bund suddenly inundated the country, and the whole camp was compelled to have recourse to boats to remove to dry land several miles distant.

A fierce nor-wester shortly afterwards blew the whole platform of the Banibon tower out of the masonry, ... and lodged it on the ground many yards distant. Fortunately no person was on the tower at the moment, but a heliotrope which had been left on the centre pillar was thrown off and crushed with violence. ...

To avoid cutting more trees than were absolutely necessary, high masts were erected on the towers in advance, ... and a blue light burned at a previously determined time, which was observed...and the angle measured to a referring mark. Flags were then placed at daylight on the bearing thus ascertained, and the ray traced in the usual way. ... On one occasion, however, ... Mr. Nield...[mistook] a lantern at the mast-head of a ship at anchor in the Hooghly for a blue light burned at the advanced station.

The number of trees felled during...this season amounts to 2908, for which compensation was paid amounting to rupees 933-7-6.

The native establishment...has been very healthy during the past season's operations. One man fell from a scaffolding and broke his leg below the knee. He was sent by water to my camp where the native doctor...reduced the fracture[3].

Towards the end of the season Hill went sick and the later observations were carried out by Clarkson. In all, nine principal triangles were completed, carrying the series as far as the side Mirzāpur–Sarisāl, astride the Hooghly above Diamond Harbour. The party took the field again on 27th November 1848, when Hill re-observed the vertical angles at Mirzāpur and Sarisāl.

Many troublesome and vexatious delays took place from the inundations having only partially subsided, and [from] the deep mud which covered...the country which was not submerged [19]. The mornings, evenings, and nights at this period...are generally foggy, but the afternoons...are favourable for observing the vertical angles at Sarsia and Mirzapore, and discover the evident discrepancy in the observations of last season. This, it would appear, arose from...the ray passing close over a village, the smoke arising from which must have affected the observation at Mirzapore[4].

[1] centred on Nibria TS.; *GTS. Syn.* XII, Calcutta Longl.; chart 3. [2] DDn. 508 (182), Hill to SG. 20-7-47. [3] ib. (281), Hill to SG., 8-7-48; v. *GTS. Syn.*, XIII (cii-C). [4] DDn. 508 (354), Hill to SG., 22-8-49.

This re-observation had to be repeated the next season, 1849–50, when Clarkson had great difficulty in getting the instrument carried across submerged rice-fields—across the Hooghly to Budge-Budge—over tidal creeks where bridges had been washed away—making only about six miles a day. He had to raise both towers before he could get vertical angles at the time of minimum refraction.

James was employed on fixing semaphores and other navigation signals, observing "to blue lights burned over the staffs". Nield was employed on building towers, one of his troubles being "the quantity of salt in the soil, rendering it unfit for bricks". Some of the towers collapsed before they could be brought into use [108-9]. It frequently happened that when towers were revisited the following season the rays had been closed by the growth of vegetation, and the towers had to be raised and further height gained by trestles of 10 to 15 feet high.

By the end of February 1849 the advanced triangles had been worked forward to make junction with Boileau's stations of the Parasnāth series west of Balasore [IV, 60], and Hill now arranged for a connection to sea-level [23];

A graduated tide-gauge was erected south of Gangra about half-way between that station and Kedjeree, ... and with the assistance of Mr. Bedford, river surveyor [71], ... arrangements were made to register the rise and fall of the tide with regularity. ...

By the 12th March my observatory was on the tower at Gangra for observations...for azimuth, but clouds...so effectually obscured the sky that...from the 20th March to the 11th April not one regular set...could be obtained. ... The several rays from Gangra were...being cleared,...and preparations were made to connect...Gangra with the tide-guage [71].

Work was held up by an outbreak of malaria after which

the final angles at Sarisa were completed and the camp moved to Ramnagar. ... The weather grew daily more unfavourable; heavy storms from the north-west accompanied with much rain were of frequent occurrence, and on removal to Natsal...a severe storm at night split several of the tents and did damage otherwise. ... Those who had been sick suffered relapse on their using much exertion. All idea of obtaining final observations was...reluctantly abandoned, and the party returned into quarters [26, 463]. ...

The whole of the triangulation of the principal series to the junction at Nilgiri with the southern part of the Parasnath series is laid out, and there remains but one new tower to be built, and three towers now 20 feet high to be finished, exclusive of 5 towers on the Southern Maluncha Series to effect junction with the Coast Series[1] [pl. 3].

During season 1849–50, Clarkson and James observed final angles along the coast, whilst Hill laid out the southern stations of the Maluncha Series [23]. Clarkson found it impossible to run ray-traces by perambulator in the swampy country of Hijli which was "interesected with rivers, deep muddy creeks and canals, and...with swamps and miry ground over which it is...unsafe to tread" [IV, 186 n.4; V, 103–4]. Triangles were laid out by means of blue lights and bamboo masts as in Everest's reconnaissance north of Delhi in 1833–4 [IV, 29–31].

Again the field season closed with disaster; in the middle of April 1850

sixteen men with the native doctor were prostrated by the fever peculiar to this marshy country. Mr. Clarkson was about to remove the sick to higher ground...when a fearful cyclone...swept over the country, utterly destroying his camp and spreading devastation. This was the famous circular storm or tornado of 27th April 1850 which was so dreadfully destructive[2]. The wind blew with great violence for 10 hours, ... with rain and severe gusts. The river swelled, ... overflowing its banks and, the bunds breaking, the country became submerged. The camp was inundated and most of the tents were split to pieces and blown away.

The instrument had a narrow escape from destruction. ... The private equipments of the party were completely destroyed, and obliged Mr. Clarkson to leave the field[3].

By March 1850 Hill's health had so deteriorated that he took "eighteen months leave...to sea", leaving Clarkson in charge. During season 1850–1, Clarkson connected his vertical angles to the tidal station near Kedgeree [71], and with but two assistants[4] carried the main approximate series, to just short of Balasore across the thickly wooded banks of the Subarnarekha; the clearing of one ray alone took 28 days.

[1] DDn. 508 (354), Hill to SG., 22-8-49. [2] *JASB.*, XX, 1851 (195–207). [3] *GTS.* VI & *Syn.* XIII (xiv–C); DDn. 507 (75), 28–4–50; 599 (20), 1–6–50. [4] Chas. Olliver & Wm. Low [413, 419–20].

In his instructions for the future conduct of the series, the Surveyor General directed that it should follow the seaward flank of the hills, allowing occasional single stations in the plains. Frequent connections were to be made with Saxton's topographical triangulation and with Snell's triangulation to the south by occupying identical stations whenever possible. Secondary triangles were to be thrown out to pick up cities and towns, lighthouses, and temples, and to connect up the revenue surveys.

He showed little sympathy for the disasters that had forced the party to break off field work so early as April two seasons in succession ;

The lateness of the rainy season in Bengal and Orissa [52 n.5, 463 n.5], the inundations and pernicious climate, are the cause of the Coast Series party taking the field two or three months later than [other] branches of the Survey. ... Last year you not only took the field after every other party, but returned to quarters before they did.

It appears that a few men fell sick and 2 died, which out of a party of 200 people including followers seems far from surprising. The mortality in cantonments might have been far greater, and it is altogether illogical to ascribe such casualties to exposure in tents. ... In the spring season sickness frequently prevails, and afterwards subsides as the hot weather sets in. I am not at all satisfied of the necessity on your part of leaving the field last April, and, as it was a point of vast interest and importance to have closed your work on the Parasnath Series stations, I was grievously disappointed at your not doing so [367]. ...

At the close of next field season your party will not return to Midnapore, but will proceed to...monsoon quarters at Cuttack or Pooree[1].

COAST SERIES : PEYTON, 1852–5

At the end of 1851 Peyton was deputed from Dehra Dūn to visit the party and then ordered to assume charge from 1st February 1852. There had been trouble with the lay-out of the hill stations beyond Balasore ; the assistants were inexperienced. Neither Hill nor Clarkson had sufficient experience to make a success of the very difficult conditions that faced them, and the repeated occasions when it was found necessary to raise the height of a tower at the last moment, or when towers had been built in unsuitable positions, showed serious lack of forethought. The Surveyor General was surprised to learn of the

immense quantity of work...on hand to complete the connection with the hill stations. I had formed an impression from previous reports that the whole of the plan work had been laid out—towers built—and rays all nearly cleared. I am disappointed to find...such unfavourable circumstances, several towers being wanting, and rays uncleared and undetermined. ... No part of the series can be said to be ready for final observation. ...

The extremely slow progress...is mainly attributable to want of system in laying out the work regularly and steadily. In no other series have the sites of towers long established and built required to be changed. ... In the swampy forests of the terai...the seasons have been equally limited by sickness, ... but the progress has been greater because the work has been systematically laid out without...perpetual countermarching, changing, and alterations[2]. ...

The difficulties caused by injudicious selection of stations have originated in taking everything for granted. ... It was a rule with me not to observe a single final angle until six approximate triangles had been laid out in advance. ... Without a regular ray-trace, however, it is impossible to make the best selections and avoid obstructions, nor should a ray be cut, or a tower built, until the Surveyor has gone over every foot of the ground [61, 100–2]. ...

Much reliance cannot be placed on the [height] values brought forward from the last sea-level reference. A fresh datum should...be taken up at Balasore, or any convenient place so that the heights of the hill stations may be accurately fixed[3] [23, 71].

Under Peyton's charge, season 1852–3[4] was devoted to clearing up the work that still lay in the low country north of Balasore. The Maluncha and Parasnāth series were at last linked up, and eleven triangles were completed during the season. A start was made in laying out stations in the hills to the south. But it was a disastrous season for sickness, with twelve deaths, five from fever, and seven from

[1] DDn. 591 (99), SG. to Clarkson, 26–9–51. [2] DDn. 598 (237), SG. to Peyton, 10–3–52. [3] ib. (255), SG. to Peyton, 3–6–52. [4] assts. Clarkson, Blewitt, Low, Cunningham.

cholera. Clarkson had to take sick leave to sea. Peyton concluded that field work would have to be restricted to the three months January to March[1].

During season 1853–4, a tide-gauge was set up near the mouth of the Burhabalang River, free from disturbance from either river or tidal current. Observations were taken for five weeks, and the gauge connected to the triangulation [71][2].

The main series now ran through the hill tracts of Mayūrbhanj and Keonjhar states west of Balasore and, through the greater part of Orissa, lay up to fifty miles inland from the coast. Both main and advanced parties made early retreat to Cuttack on the outbreak of fever ;

The hilly portion...was found wild in the extreme, and very thinly inhabited, the latter... attributed to the devastation caused...by the wild elephants which seldom allowed the ryot to reap his fields. Travelling was found very difficult and hazardous, clothed as the country is in impenetrable primeval forests. We had to cut our way through, ... and generally more days were consumed in marching from one station to another owing to the circuitous windings ...than in finishing with the observations[3].

For season 1854–5 the party was strengthened by the posting of William Rossenrode [45 n.2, 100], who took over the approximate series and carried it about 120 miles south from the neighbourhood of Cuttack to south of Gopālpur where the hills closed in on the coast; his right flank lay in the rough hills of the Khōnds [176]. Clarkson reconnoitred a secondary series to connect Sambalpur on the west [28]. Peyton advanced the final observations as far as Cuttack, but was again hampered by sickness, and had barely two months at work ;

By the beginning of March...it was a matter of difficulty to single out the individuals who had escaped the ravages of fever. Old veterans reckoned proof against jungle fever were laid prostrate by it. ... After...observations at...Cuttack Fort station it was found impracticable to continue out longer on field work. Both Messrs. Clarkson and Rossenrode experienced the same disasters[4] [465].

COAST SERIES : STRANGE & BASEVI, 1856–61

Peyton was now over fifty years of age, and after three very hard seasons in this pestilential climate asked permission to resign. Alexander Strange, who had completed his formidable task across the desert to Sind [38–42], relieved him in January 1856, just south of Cuttack. Taking over in such utterly different conditions, and facing a particularly unfavourable season, it is not surprising that he made but little progress before closing work by the 15th May.

I entered on the field duties at Doodua hill station[5] on 8th January. ... Mr. Peyton remained with me...and rendered me the most valuable assistance in examining, clearing, and adjusting the instrument...during 9 days. Mr. Peyton's health whilst at Doodua H.S. being far from good, ... [he] took his departure...on 22nd January, but not before he had informed me fully regarding every branch of the undertaking.

Strange had the platform reconstructed in lime instead of mud. "Lime was procured from Cuttack, and...a new platform was built...under my own eye, the stability of which was found irreproachable" [112]. Secondary stations and points also required attention ;

Either the mark was faintly engraved or it was on a small loose stone, or the pole was a mere bamboo, or there was no pile of stones, or no brush, or the top of the hill was not thoroughly cleared. ... The detention at Doodua...occupied 17 days.

After seven days at the next station it took five marches to reach Chanchania, only 19 miles away "which may give some idea of the obstructions to travelling". Dissatisfied with his triangular errors, Strange returned to Doodua for another nine days, during which there were "four very severe equinoctial gales" with enormous hailstones...3 inches in diameter[6]. ... The instrument was packed up four times...in consequence of threatening weather, ... generally...at the best time for observing. ... A haze...

[1] DDn. 599 (122), 15-7-53. [2] DDn. 601 (34), 31-5-54 ; *GTS. Syn.*, XIII (XVIII–XXIII–C). DDn. 601 (43), Peyton to SG., 27-7-54. [4] DDn. 601 (99), Peyton to SG., 28-5-55 ; *GTS.*, VI (XXIV–C). [5] 30 m. sw. of Cuttack. [6] I have seen hailstones the size of tennis balls at Murree, July 1943 ; the noise on an iron roof was most alarming ; RHF.

gradually extended over the whole country. Neither our heliotropes nor our lamps could penetrate this haze for 11 days, and...I did not obtain a single terrestial observation. It was generally clear however overhead, ... so the time was not altogether lost,

for he instructed his recorder in making astronomical observations and designed "a new slow-motion apparatus for the 24-inch theodolite".

The jungles began to burn. We were on one occasion...up the greater part of the night diverting the fire from the tents. The next day, when the wind lulled, I led a line of fire round the whole encampment...and...we had no longer anything to fear [IV, 69–70].

At the next station it took 19 days to observe only two principal angles. At Dhanai, about ten miles north of the Chilka Lake, erratic refraction at midday frequently caused heliotropes to subtend from 20 to 30 seconds ; in the morning they were sometimes fit for observation, though never steady or well-defined. Strange took a gloomy view of future progress ;

I cannot concur...in believing that the Coast Series will soon emerge from those difficulties and impediments that have hitherto retarted its progress. ... The country traversed by me this year is perhaps the most favourable that we shall for several seasons meet with, ... a mere oasis in the desert of unpeopled jungle and hills. Mr. Rossenrode reports that next season's work will lie in a tract without roads and almost without population ; ... a mere sea of bamboo jungle, nearly impenetrable. The hills are high and the passes are few. ...

I was, perhaps, in as healthy a tract this year as is to be found on this side, and yet sickness set in steadily towards the end of January, never left the camp, and at times nearly disabled it. I believe that there were not more than four individuals of the party, of whom I was one, who escaped fever, and the greater number had more than one attack. ...

I do not at all mean that I expect the series to creep on in that snail's pace at which it advanced during the late season. I...trust...no future year will exhibit so sorry an outturn[1].

Rossenrode had pushed the approximate series forward beyond Vizagapatam "with the spirit and success for which that gentleman is justly famed", but at the start of season 1856–7 a warning was received of tribal disturbances in the Ganjam hills south of the Chilka Lake, and he went forward with a strong escort to re-arrange the triangles as a single series.

By the time Strange had brought his observations to the Ganjam border his party was riddled with sickness. Seven men had died of cholera, and practically all were saturated with fever. Eventually he succumbed himself, and was forced to take long leave to the Nilgiri hills [379][2].

Clarkson completed his secondary series to Sambālpur, staying out till June [27]. A minor series running northward along the Orissa coast from the Chilka Lake has been started by Charles Shelverton, and this was now taken over by the topographical parties under Saxton and Depree, who were unable to continue their programme towards Sambalpur on account of local disturbances [173–4].

During season 1857–8 Clarkson carried observations six triangles to the south before going back to revise his work because of large triangular errors which he attributed to a defect in the theodolite. The Surveyor General considered this a great waste of time, especially as there was no apparent improvement in results. He ordered that the series should revert to the form of polygons and quadrilaterals where the hills swung away from the coast.

Starting season 1858–9 with a new 24-inch theodolite [154], Clarkson extended the main series from Berhampore to the neighbourhood of Chicacole, having only two assistants posted from Saxton's party ; Rossenrode had been transferred to Assam[3]. Strange resumed charge in August 1859, and during season 1859–60 brought the series down to Vizagapatam, where he established a tidal station. Clarkson extended the approximate series to Nalakonda, some 35 miles west of Vizagapatam[4], whilst Ellison and Howard ran a minor triangulation along the coast line started southwards from Ichhapuram near Berhampur[5].

Having been now promoted regimental major, Strange had to revert to military duty, and handed over to Clarkson on 9th August 1860 [382]. Pending the arrival

[1] DDn. 698 (66), 3–6–56. [2] *GTS.* VI, & *Syn.* XIII (XXIX–C). [3] Rossenrode transferred Sept. 1858 ; James Smith resigned & Penny was dism. [420]. [4] *GTS. Syn.* X (IV–B) start of Bidar Longl. [5] *GTS.* VI, & *Syn.* XIII (XXII–X–XII–C).

of Basevi, Clarkson completed the tide-gauge at Vizagapatam, and recorded two months tidal observations[1].

Basevi took charge on 1st December 1860, the series being now renamed the Madras Meridian and Coast series. By June 1861 he had completed observations to complete three polygons and one quadrilateral, having crossed the Godāvari at Rājahmundry and swung away from the coast towards the Madras meridian. Clarkson carried the approximate series forward to the Kistna, and Howard continued the minor series along the coast as far as Cocanāda[2]. The base-line near Vizagapatam was measured at the end of 1862.

Commenced by Hill in 1847 the Coast Series had been brought some 600 miles to the Godāvari by 1861. It had been taken through the flat, thickly populated, creek-intersected, plains of Midnapore, and then through the deserted hilly jungles of Orissa and Ganjam, all teeming with malaria and dysentery, and cursed by a pestilential climate. Officers, assistants, and followers were continually sick, and frequent transfers were necessary. Clarkson had richly earned his pension in 1864 having had but three months leave in some twenty years [415–6].

ASSAM LONGITUDINAL: DU VERNET, 1853

During his stay in Darjeeling for the rains of 1847 the Surveyor General laid plans for extending the North-East Longitudinal series eastwards into Assam. He first consulted Francis Jenkins, Agent to the Governor General for the North-East Frontier [IV, 449], and Thomas Fisher, who had for many years been surveyor in Sylhet and Cāchār [III, 447-8]. He concluded that whilst the first hundred miles would run through Cooch Behār and north Bengal—dead-flat country as far as the great southward bend of the Brahmaputra—triangulation along that river would be facilitated by the isolated hillocks that are a feature of lower Assam[3].

In October 1852, having completed the North Parasnāth series, Nicolson marched his party up from Monghyr to the Sonakhoda base to start the new longitudinal series from the Rāmganj polygon at the head of the Calcutta Meridional series [16]. He began by observing an astronomical azimuth at the north end of the base, but got no further when his party was prostrated by fever.

On 1st January 1853 he was relieved by Du Vernet who had been selected for permanent charge, and at the end of the month the party was inspected by the Surveyor General who directed that across the flat country the series should consist of a chain of hexagons and pentagons, with sides about 11 miles long, and towers about 25 feet high. Early in May Du Vernet brought the approximate series eastward to beyond Cooch Behār, having observed at three stations, including two of the N.E. Longitudinal. Work had been hampered by fog and fever and, writes Du Vernet,

> I could make little progress on account of the unfavourable state of the atmosphere. ... The heliotropes did not become intersectable until late in the evening. Nothing but a full heliotrope could pierce the thick atmosphere, and the sun near half-an-hour before setting became obscured in mist, ... so that about an hour each day remained for work. ... At night the lamps were not visible, and in the evenings they were only occasionally intersectable for half-an-hour after sunset. ... On few occasions was I able to work for a longer time, but often lost the observations altogether. It is very distressing and trying to the patience. ...
>
> The approximate work was not fairly commenced until January, and at that time near fifty men were on the doctor's list[4].

The Surveyor General thought that field work had been broken off too early—atmospheric conditions generally improved during May and June—and that Darjeeling or Gauhāti would have been more accessible for recess. Du Vernet replied that Dacca was reasonably accessible by river and far more agreeable to his followers than Darjeeling; he had not closed work until the start of the rains and he definitely

[1] DDn. 697 (127), Clarkson's note, 13–8–60 & SG.'s, 3–9–60. [2] ib. (130); Basevi, to srs., 25–6–61; asstn., Clarkson, Howard, Ellison, F. Ryall. [3] DDn. 464 (223–8), 15–6–47; 463 (499–505), 26– & 29–6–47. [4] DDn. 602 (158), 4–5–53.

objected to working through "the height of the monsoon; ... I do not think that four months was an over-long time for laying out 22 triangles, building 12 towers, and cutting 31 rays" [369][1].

He complained of his theodolite, Waugh's 24-inch No. 2, but the Surveyor General pointed out that it had been successfully used—at one time or another—by Logan, Strange, and Renny-Tailyour, the last-named having reported it "hardly inferior to the Great Theodolite" [21, 148, 153]. He called for a copy of Du Vernet's angles at his three stations and sent them to these three officers for comment. As all three, without mutual consultation, reported them unfit for principal triangulation[2], the Surveyor General insisted on Du Vernet's resignation [394–5]. Nicolson was directed to resume charge.

ASSAM: NICOLSON, 1853–6

Before the start of season 1853–4 Waugh impressed on Nicolson that

> the Assam Longitudinal series is essentially a work of the highest order, not only for its great length, but also on account of the number of subordinate series that will depend on it. I... enjoin upon you to bestow the utmost care and refinement possible. ... I would also direct your earnest attention to the importance of always keeping your approximate party well ahead[3].

Charles Shelverton took the approximate series forward to the Brahmaputra, laying out a series of hexagons, with a total of 23 tower stations in the plains and 7 hill stations along the river. He had to break off early in May with his whole detachment down with fever. He was again unfortunate the following season, erecting only seven more tower stations.

Nicolson himself found much to be done on Du Vernet's line before observation could be started. Rays had to be re-cleared; towers had collapsed and had to be rebuilt on a different design. In both seasons a civil official was deputed to settle compensation for the clearing operations.

> Of the towers...constructed during the previous season, those which were made entirely of brick had fallen down, and...others built partly of bricks and partly of earth supported by wooden piles, although standing, were neither trustworthy nor of sufficient height to enable the vertical observations to be taken at the proper hour of the day. ...
>
> [For the new towers] the bricks used in the building of the pillars were excavated from old ruins as, partly owing to the unsuitableness of the soil, partly to the moist character of the atmosphere, but chiefly to the uncertainty of procuring a regular supply of coolies, ... it was found impracticable to follow the usual course of making them on the spot[4].

He could not start final observations before the middle of March, and had first to re-observe Du Vernet's angles. Though he had only completed five stations by the end of April he held on till the rains cleared the air and by mid-June had observed at eight more stations, forming one double and one single hexagon, before retreating to recess quarters at Darjeeling.

From an examination of Lane's observations of the Rāmganj hexagon at the Sonakhoda base, the Surveyor General suspected that there had been some settlement and deflection of the towers which were of the solid type [107]. For season 1854–5, therefore, Nicolson was directed to repair those towers that required it, and to reobserve all the angles affected, as well as those connecting the Assam series [19]. This took him nearly five months, and then by the end of June 1855 he extended the main series by two more hexagons to cover Cooch Behār.

During season 1855–6[5] Nicolson himself took charge of the forward work, and with some re-arrangement of Shelverton's lay-out carried the approximate series beyond Goālpāra. He then started final observations near Goālpāra, intending to complete the hilly tract before working westward to meet his earlier work at Cooch Behār. At his third station he and the whole of his camp were prostrated with fever, and on the 14th May he started back to recess at Darjeeling.

[1] DDn. 602 (165), Du Vernet to SG., 25–6–53. [2] DDn. 569 (9), Renny-Tailyour to SG., 9–8–53; 591 (332), SG. to Du V., 22–9–53. [3] DDn. 604 (70), 2–12–53; cf. 547 (219), SG. to Mil. Dept., 7–2–54. [4] *GTS.* VIII & *Syn.* XXII (vi–X). [5] Asstts., Thos. Berrill, Chas. Shelverton, Deveria.

There was not a man in the whole establishment...who did not feel himself completely broken down in health. ... Shelverton had to take six months leave on medical certificate, at the expiry of which he was transferred to another part of India [51 n.3] ... Berrill and Deveria resigned. ... Nicolson...felt unequal to...another field season[1].

Charles Lane was deputed to take over charge [50, 415]. Leaving Dehra Dūn with two assistants[2] he reached Goālpāra on 12th January 1857. Meanwhile Nicolson had taken the field, and started to re-clear the rays in the region of Dhubrighāt, and to rebuild a number of towers that had collapsed during the river floods. He then started observation of angles, but went down with fever at his second station, and had to be carried in to Goālpāra where he handed over to Lane on 13th January. Taking the first steamer down the river to Calcutta, he sailed on furlough to England.

ASSAM : LANE, 1857–9

Lane kept the field right through from January to July 1857, and by remarkable perseverance carried observations from Cooch Behār to Goālpāra, in spite of heavy rains. William Dyer extended the approximate series towards Gauhāti before repeated attacks of fever compelled him to take sick leave. Recess was spent at Dhubri Ghāt where the party was joined by Dr. Lee as medical officer [461].

Being delayed by the difficulty of obtaining *khalāsis* and other followers, and by alarms about the approach of a body of mutineers from Dacca [482–4], the party did not take the field till the end of December, and had made but little progress before retiring into recess at Goālpāra at the end of April. As Dyer's health showed no signs of recovery, he was replaced by William Rossenrode from the Coast Series [28, 99], an experienced and indefatigable surveyor who had proved his worth in the Bihār *tarai*—the deserts of Rājputāna and Sind—and the hills of Ganjam. He now proved a tower of strength on the eastern frontier. With his assistance Lane brought the triangles to just short of Gauhāti. Work was closed during April and the party moved to recess quarters at Cherrapunji in the Khāsi Hills.

Lane's health had been considerably shaken during the last three seasons, and he handed over to Rossenrode on taking four months sick leave from November 1859. Rossenrode was preparing the extension of the longitudinal series up the valley when he received orders to break off and start at once on a new line running southwards across the Khāsi Hills to Sylhet [2, 362].

EASTERN FRONTIER 1859–61

Lane had been pressing the immense difficulties of carrying on the main longitudinal series up the Assam valley, and through the heavily wooded hills to the south of the Brahmaputra. There were exceptional difficulties in obtaining transport, and the heavy expense incurred by all officers called for special increase of allowances. The country was most unhealthy, and the whole establishment was continually liable to fever. But almost the greatest difficulty was the impossibility of finding labourers or recruiting survey followers from the people of Assam. Suitable men of energy had to be imported from Hazāribāgh or other distant parts. Lane supported his recommendations by letters from the civil authorities ;

You would nowhere experience so much difficulty in prosecuting...your survey as in Assam, not only from the nature of our hills and forests and the unhealthiness of the climate, ... but from the great aversion of almost all classes of Assamese to act as coolies. They have been rendered so independent from the great demand for their labour at the tea plantations that they will not take any service but such as is most agreeable to them, and I fear your work is not such as they like, and we cannot compel them to labour, even for Government [454].

[1] *GTS.* VIII & *Syn.*, XXII (ix–x). [2] H. Beverley & Wm. Dyer.

Supplies for your people will not be one of the least of your cares and difficulties. The country now before you for the next season's work is a still more difficult one than any you have yet encountered, and you must go prepared with everything. You will not be able to depend on the villages for anything. The population is very scanty, and more uncivilized than any you have yet met with [461–2][1].

The Surveyor General suggested that, as an alternative to incurring expense on the longitudinal series, the party might work on one of the meridional series east of Calcutta that was planned for the future. Government was in no position to increase its financial obligations, and accepted the proposal to divert the party to a less expensive area. Even though orders had been requested by telegram, decision came so late that the Surveyor General decided to keep the party on the Gauhāti meridian running south through Sylhet, and his orders to this effect, reached Rossenrode on the 5th December. The new series would fix

Cherra Poonji, the stations on the road from Gauhati to Cherra, Sylhet, and Jaintia. ... The principal series should be a succession of polygons or quadrilaterals. The Khasi hills are extremely favourable for triangulation, and remarkably healthy. ... Sylhet and Jaintia are free from difficulties and insalubrity. The work is in the vicinity of your monsoon quarters, and there will be no delay in reaching your ground[2].

Rossenrode promptly called in Beverley from reconnaissance up the valley, and together they laid out the first hexagon southwards into the Khāsi Hills. Then whilst Beverley continued the approximate series through Cherrapunji Rossenrode returned to Gauhāti to start observations. Lane resumed charge on 14th March[3].

There was much delay during 1860 from the unsettled state of the country. Insurgents from Jaintia were marching on Cherra, and troops were out to deal with them. Rice could not be obtained in the Khāsi villages, and had to be brought up from Gauhāti or Cherra. Labour was almost impossible to obtain owing to the demands of the military engaged against Jaintia.

The rheumatism this season has been very severe owing...to the want of animal food, to the use of hardly any clothing, to the bleak winds, and to getting wet constantly from rain on the line of march. There were no fewer than ten cases of this malady among the establishment on arrival in quarters[4]. ...

The obtainment of coolies through the civil authorities has been stopped...for all persons indiscriminately. ... Hire has risen some 50%, coupled with the greatest difficulty in procuring them. In the district of Sylhet coolies for tower building are reported by Mr. Rossenrode to demand 8 annas each per diem, and he has been obliged to entertain Cossyahs on monthly wages for the purpose[5].

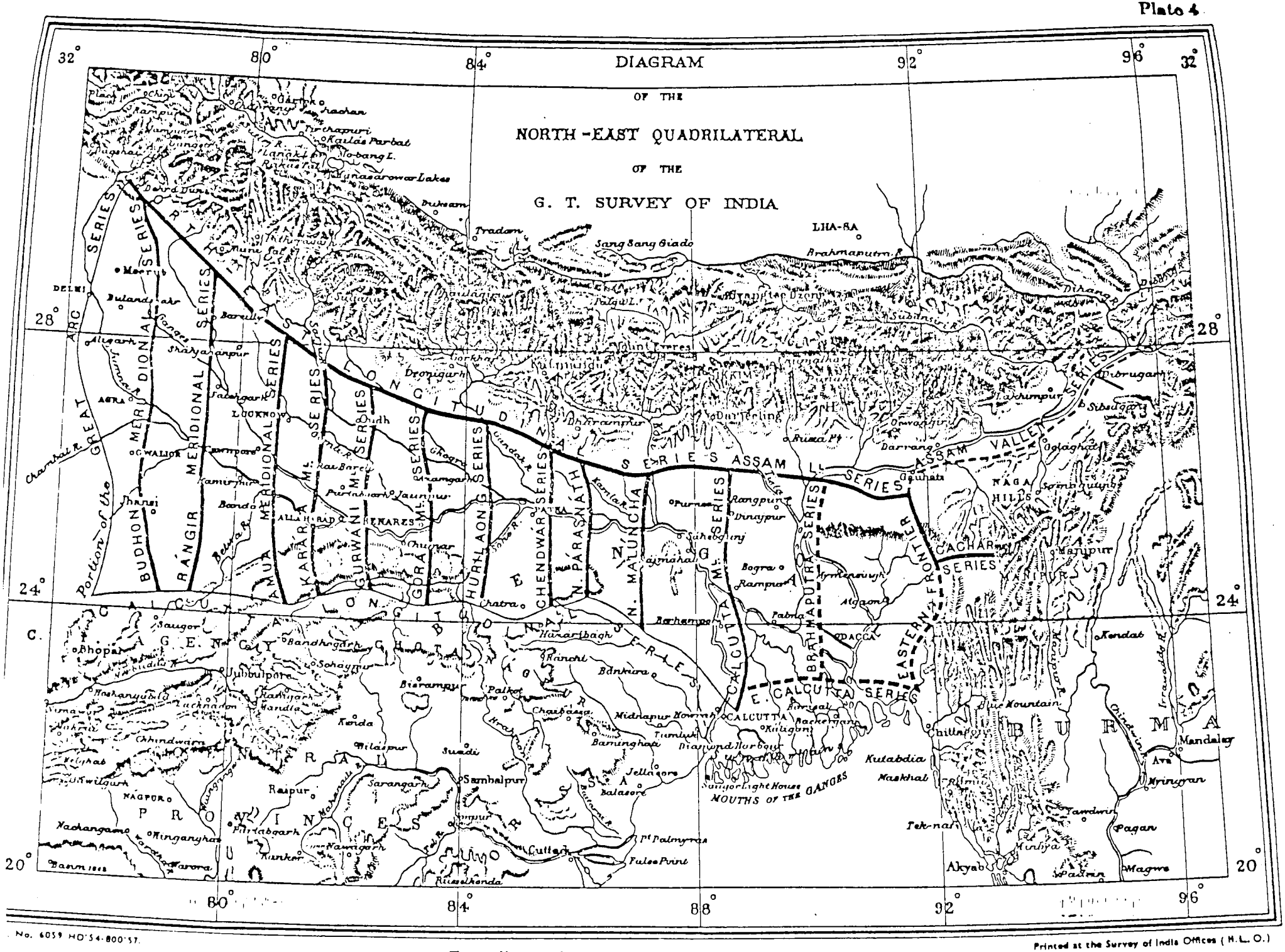
In consequence of a recent prohibition regarding impressment of coolies, although the majority of the Cossyahs are porters by trade, great difficulty and...delay were experienced in procuring these people. ... They were eventually obtained from the Rajah...as a personal favour through an influential Cossya sirdar, ... who was subsequently entertained on monthly pay, as well to facilitate our intercourse with the people...as dubash, or interpreter[6] [III, 410–11 ; V, 39, 174, 477].

During season 1860–1 Lane had employed one of his junior assistants, De Souza, who had been with a topographical party in Orissa [422], in making a topographical sketch[7] of the Khāsi plateau, hitherto mapped only from casual route surveys [IV, 446, 464]. Though this had been done at a suggestion from the chief draughtsman at Calcutta, the Surveyor General, Waugh, considered it a misuse of a trigonometrical survey officer[8]. On the other hand the Assam Government were delighted. Their summer quarters had long been settled at Cherrapunji, but they were planning a move towards Shillong. The Deputy Collector had told them that

Mr. Lane produced a most beautifully executed topographical map of the country extending from Nunklow[9] to the foot of the hills at Terriah Ghaut, ... an area of 1,000 square miles. ... If he obtained a sum of only 1,300 rupees for contingent expenses, and the loan of an additional assistant from one of the other survey parties within the next two years...he would...be able to complete an entire topographical survey of the whole of the Khasi and Jaintia Hills[10].

[1] DDn. 702 (74), Jenkins to Lane, 30–4–59. [2] DDn. 65 (38–41), SG. to Lane, 14–11–59. [3] *GTS.* VIII ; *Syn.* XXI (iii–v—w). [4] DDn. 63 (54), Lane to SG., 21–5–60. [5] ib. (77) 1–12–60. [6] ib. (98–100). 8–6–61. [7] on ¼-inch scale. [8] DDn. 65 (63), SG. to Lane, 11–12–60. [9] Nongkhlao [III, 64, 529]. [10] DDn. 61 (67), 19–7–61.

Plate 4

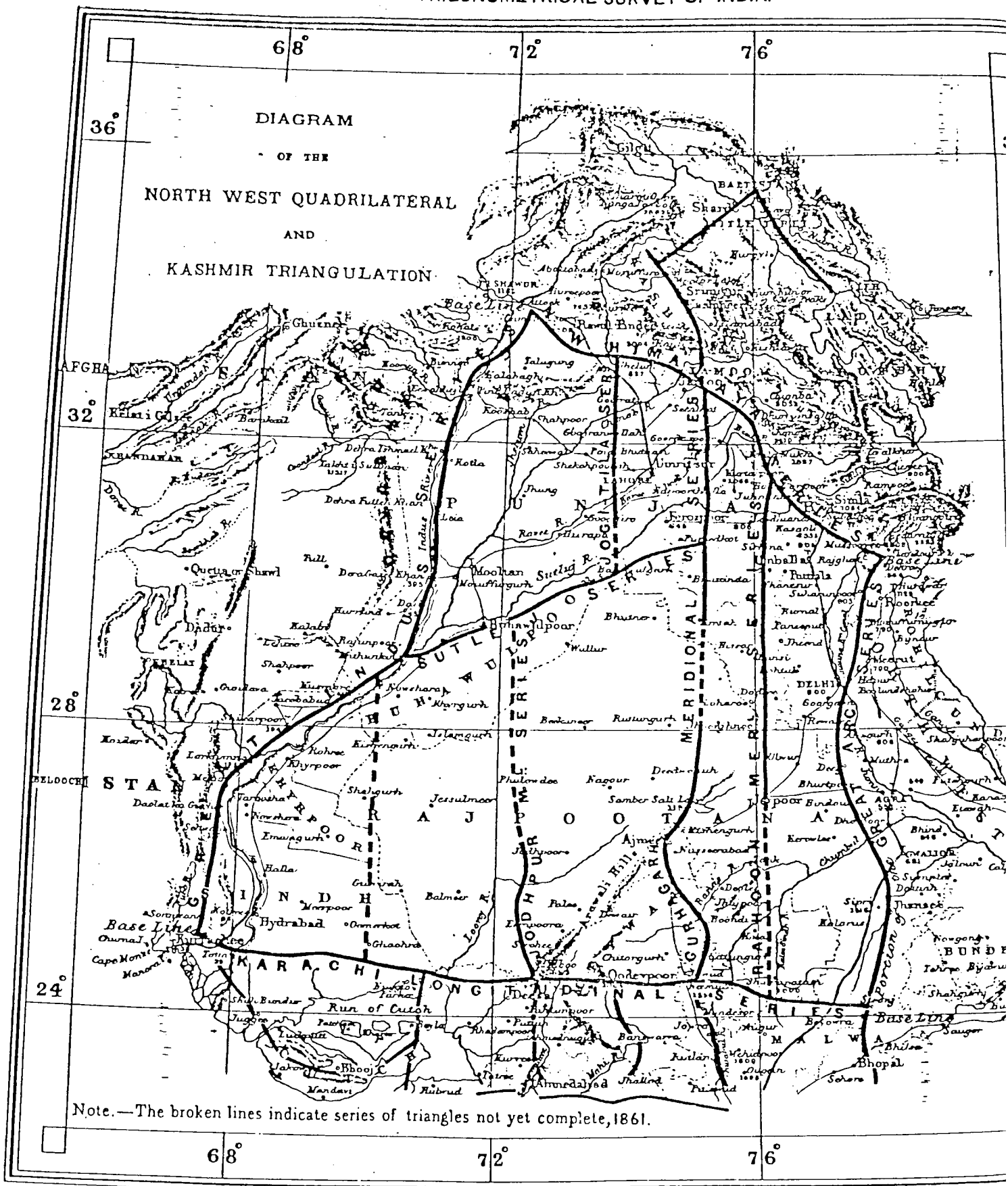


No. 6059 HO'54-800'57.

Printed at the Survey of India Offices (H.L. O.)

Plate 5

GREAT TRIGONOMETRICAL SURVEY OF INDIA.



Note.—The broken lines indicate series of triangles not yet complete, 1861.

Reg. No. 6060 HD'54-800'57.

From diagram photo-zincographed at Dehra Dun, 1874.

Printed at the Survey of India Office

Walker, now Superintendent of the Trigonometrical Survey, had no officer he could possibly spare for such employment, and Thuillier who had become Surveyor General told Government that though Lane could not take up the full survey of the Khāsi Hills, he had been authorised

as a special case to complete the rough sketch he has already commenced, if the local authorities are still anxious for such a survey, and are prepared to accept its deficiencies. ... I have recommended him to take a planetable himself, and share the topography with Mr. D'Souza, leaving to his assistants, Messrs. Rossenrode and Beverley, the conduct of the principal triangulation[1].

By the close of season 1860–1 observations on the principal series had been completed down to the Surma valley, whilst an approximate branch series had been carried east to Cāchār. Work was interrupted during March and April by heavy thunderstorms;

The roof of the Sylhet mission house, a strong and substantial bungalow, was blown bodily away. The whole of the bunder bazar on the banks of the Soorma was utterly destroyed, and no vestige of it left. Some new sepoy lines were likewise blown away[2].

By the time the party returned to recess at Cherrapunji, the whole plain below had become a vast sheet of water.

Lane carried on the Eastern Frontier series southwards towards Chittagong till he handed over charge to Rossenrode in 1865.

[1] DDn. 6 (170), SG. to Mil. Dept., 26-10-61; cf. 29 (97), to AGG. NEF., 26-6-61. [2] DDn. 63 (98–100), 8-6-61.

CHAPTER IV

NORTH-WEST QUADRILATERAL

NORTH-WEST HIMĀLAYA LONGITUDINAL ; *Du Vernet, 1847–50 — Logan, 1850–2* — GREAT LONGITUDINAL, *1848–53* — BASE-LINES ; *Chach, 1853–4 — Karāchi, 1854–5* — GREAT INDUS SERIES, *1852–6 — 1856–60* — INTERIOR SERIES ; *Rahun, 1852–3, 55–7, 60–3 — Gurhagarh, 1847–9, 58–62 — Jogi-Tila, 1853–7, 62–3 — Sutlej, 1860–3.*

IN March 1846, following the first Sikh war of 1845-6, the British took possession of the Jullundur *doāb* which lies between the Beās and Sutlej rivers, and the rest of the Punjab became a "protected territory", with a British Resident at Lahore [2, 7, 269]. In November the Surveyor General was called on to arrange for "a chain of triangles to be stretched to the north-west as far as British influence will admit"[1]. As the Bengal parties of the Great Trigonometrical Survey were fully engaged on work to the east, this new work could not be undertaken until after the rains of 1847, when Du Vernet's party, which had just completed the Gurwāni series through Gorakhpur, was moved to Dehra Dūn to start a new longitudinal series running west from the Great Arc [12].

Du Vernet had considerable survey experience not only on topographical survey in hilly districts in Madras and Hyderābād, but also since 1841 with the G.T.S., on the North Connecting series through Garhwāl and Kumaun, and on the Karara and Gurwāni meridional series [IV, 71 ; V, 11–2].

The Surveyor General planned a four-sided figure of triangulation with the Great Arc on the east, the North-West Longitudinal on the north, the Great Longitudinal on the south, and the Great Indus series following that river on the west[2]. Each of these was to be measured with the highest order of accuracy, with the best available instruments, and to close on measured base-lines [149] ;

Lastly we have the subordinate meridional series. These are in the nature of filling-up operations and any errors generated on them, being detected by the longitudinal series on which they depend, can easily be dispersed [pls. 3, 5][3].

The first to be put in hand was the North-West Himālaya longitudinal series, starting from the side Amsot–Banog astride the Dehra Dūn base-line, and closing on a new base-line to be measured in the Chach valley near Attock [42–3 ; pl. 7][4]. It passed along the foothills through Sirmūr and Nāhan into Hoshiārpur and Kāngra, and then through Jammu and Rāwalpindi.

It was decided that a 3-ft. theodolite would be too cumbersome for transport in the hills, and that the new 24-inch by Mohsin Husain would be more suitable[5].

The experiments...shew that angles measured therewith can be relied on to less than half a second [149, 152]. The azimuth circle is a beautiful specimen of Messrs. Troughton & Simms hand division, and the telescope is extremely clear and capable of being used with a power of 70 for...terrestial objects. The vertical circle is also very superior, and as I intend that the... principal triangles shall be disposed in polygons and quadrilaterals, I have no doubt that the work will take rank as a geodetic undertaking of the first order[6] [152–3].

The Surveyor General writes to the Resident at Lahore ;

I have directed Captain Du Vernet to break ground early in October at the Dehra Dun base, and carry the principal triangulation forward with vigor. He may, therefore, be expected to reach the Sutlej in the spring of 1848. ...

[1] DDn. 461 (113), from GG.'s Camp, 28-11-46. [2] NW. Quad. ; *GTS.* I (12–4) ; III. [3] DDn. 325 (523-52), SG. to Rivers, 7-10-47 ; *GTS.* IV (4–5). [4] NW. Himalaya ; *GTS.*, III, (iii–xii—C) & *Syn.* VII (1–42—C). [5] Waugh's 24-inch No. 1 [148]. [6] DDn. 462 (100–8), SG. to Mil. Dept., 12-2-48.

With regard to the series...down the valley of the Indus from Peshawar to Karachee, ... it will hardly be possible to commence that work much before...the N.W. series may...reach the vicinity of Peshawar, because it will be difficult to render more than three parties... available. ... There are seven parties of the G.T. Survey in all. Of these one is now employed on the Coromandel Coast, another on the Bombay coast, and a third will be engaged on the very important work of carrying a longitudinal series along the parallel of 24° from Sironj to Karachee, in continuation of the Calcutta Longitudinal Series [37–42][1].

In addition to the main triangulation Du Vernet's party was to make a general survey of the hills to the north. He was to keep

the principal triangulation as far to the south as practicable. The northern portion of the hilly regions can be most conveniently laid down by secondary work. ... Lofty mountains can be visited for secondary purposes with a small theodolite at the precise season when those stations are most easily accessible, the angles being taken to...pole and brush, which when once fixed remain always ready for observation. ... It will be an object of importance to form a complete military map on a scale of two miles to the inch. ... The elevations and positions of the snowy peaks will be best fixed from the principal stations, and as these secondary triangles will be very large their spherical excess will need to be computed [82, 282]. ...

An allowance of 100 rupees per mensem has been sanctioned to the officer in charge for conveyance of his baggage in the mountains. This allowance will be drawn throughout the year, and is in the nature of a contract, ... no account of the expenditure being required. ... A similar mountain allowance of 60 (sixty) rupees per mensem has been sanctioned for each sub-assistant...throughout the year [375, 405–6][2].

During his first season, 1847–8, Du Vernet completed 19 principal triangles up to Rūpar on the Sutlej, the right flank resting on hills from 4,000 to 9,700 feet and the left on the Siwālik range, with a network of secondary triangles from which snow peaks were fixed. A general map was kept up on the ¼-inch scale and the old survey by Hodgson and Herbert rectified and filled up [III, 31–40]. Two Madras officers, Halpin and Strange, were attached for instruction [371, 379, 385][3].

In March 1848 trouble flared up at Multān, and by September the whole Punjab was involved in the 2nd Sikh war[4]. Du Vernet's party had taken the field in Hoshiārpur in October, and had to retreat to Kālka ;

Captain Du Vernet did not leave Dehra till the 13th of October and he had made but small progress...when an insurrection broke out in the valley of the Saon, or Jaswan Dun, which drove the whole party from the field.

Captain Du Vernet with a large theodolite narrowly escaped capture, but Sub-Assistant Mr. C. Olliver was less fortunate, and was made prisoner by the rebels, who plundered his property and destroyed one of the 12-inch theodolites[5] [162]. ... Mr. Olliver was marched off... as a prisoner to the Rajah at Amb, and after undergoing considerable privations during a captivity of 8 days, was eventually released by a detachment of the 29th N.I. ... After these adventures he returned to headquarters in good health, but with the loss of all his equipment, for which he ultimately received compensation, 800 rupees [474][6].

Work was resumed in January, and the main triangles carried forward to the Beās [pl. 6]. Keelan and Mulheran were employed on minor triangulation southward to the Beās–Sutlej junction and north to Mandi[7]. During the next season, 1849–50, Du Vernet advanced to the borders of Jammu, and obtained permission from Mahārāja Gulāb Singh to enter his territory. Unfortunately local objections were raised to the occupation of Trikota or Tirebtar [36–7, 479–80],

a mountain ten thousand feet high, very difficult of access, and in part covered with snow, at the south base of which, in a deep ravine eight miles from the peak, ... is a Hindu temple. A barkandaz...accompanied by several persons deputed by the Maharaja's people...proceeded to the Tirebtar mountain to build a station on the highest part of the rocky peak. They there found a stone...having a rough figure on one side about 8 inches high. ... The Kotwal accompanying the barkandaz, and in the service of the Maharajah, displaced the stone to make room for my station.

A formal complaint came through from Lahore that a sacred hill had been desecrated and Du Vernet had to withdraw his party ;

[1] DDn. 462 (130–4), 12–5–47. [2] DDn. 492 (58–71), 12–6–47; Assts. James Mulheran, Chas. Olliver, Blewitt, J. Dyer, Pierce, & Burt. [3] *GTS.* III (iii–xii—C) *Syn.*, VII (li—C); DDn. 462 (265–307), 16–1–49 (37). [4] battles Chiliānwāla, 13–1–49 ; Gujrāt, 21–2–49 ; treaty, Rāwalpindi, 14–3–49. [5] sent to England for repair. [6] DDn. 542 (37), SG. to Mil. Dept., 28–8–50. [7] *GTS.* III (iv—C), *Syn.* VII (li—C).

Great pecuniary loss has occurred, but the orders of the Board at Lahore, ... together with the Maharajah's objections to my occupying any part of the Tirebtar mountain for a station, left me no alternative. I was obliged to sacrifice the whole of my work[1].

According to the Surveyor General the objection arose entirely from misconception of the localities, because the summit of the mountain, which is about 10,000 feet above the level of the sea, is situated full 8 miles from the sacred temple, and I have no doubt that if the matter had been amicably explained to His Highness the prohibition might have been removed...but, as the President of the Board of Administration took an unfavourable view of the subject, it became necessary to abandon Trikota as a principal station[2].

The secondary operations, comprising both triangulation and half-inch plane-tabling, now extended for a width of about 150 miles and were of high importance. The Surveyor General therefore, directed Du Vernet to give his whole attention to this topographical work, whilst Logan who had become available from the North-East Longitudinal [18] took over the principal triangulation.

I propose...to place Mr. Logan's party upon the principal triangulation to which his attention will be entirely confined, while Captain Du Vernet will be engaged in the topographical details of the mountains, which will also require his undivided care [200][3].

Du Vernet's party at this time numbered no fewer than nine sub-assistants[4], of whom Keelan had been detached for several months of season 1849–50 on a route survey of the Surveyor General's journey to Peshāwar [202, 337]. On his return he had carried minor triangulation down the Beās river to the Sutlej.

NORTH-WEST HIMĀLAYA ; LOGAN, 1850–2

Logan's party was now designated the Second Hill Series[5].

Mr. Logan will prosecute the principal series towards Peshawar...with the greatest possible rapidity. ... This is a point of very great importance in order to supply the means of connecting as speedily as possible the various detached and desultory surveys which have been executed in Hazara, Peshawar, etc., as well as to furnish a proper basis for new and systematic survey in the contiguous parts [210, 296]. ... Mr. Logan will take the field at the close of the monsoon, and proceed to the town of Samba...about 18 miles south-east of Jamboo[6].

The Surveyor General further ordered that the series should follow as straight a course as practicable to the plain of Chach immediately north of Attock, but it will be desirable to avoid mountains above 6,000 or 7,000 feet high as principal stations because they cannot readily be visited in the winter season for final observation. ...

All remarkable mountains on your north flank, as well as conspicuous hills to the south, should be marked as secondary stations, and duly connected. ... It will also be desirable to fix one or more points in all towns [and] cantonments. ... I need not point out the advantage of fixing the positions and altitudes of as many snowy peaks as you can determine, more particularly of the Pir Pinjal range, and the snowy peaks seen over the Chamba range [86–7]. ...

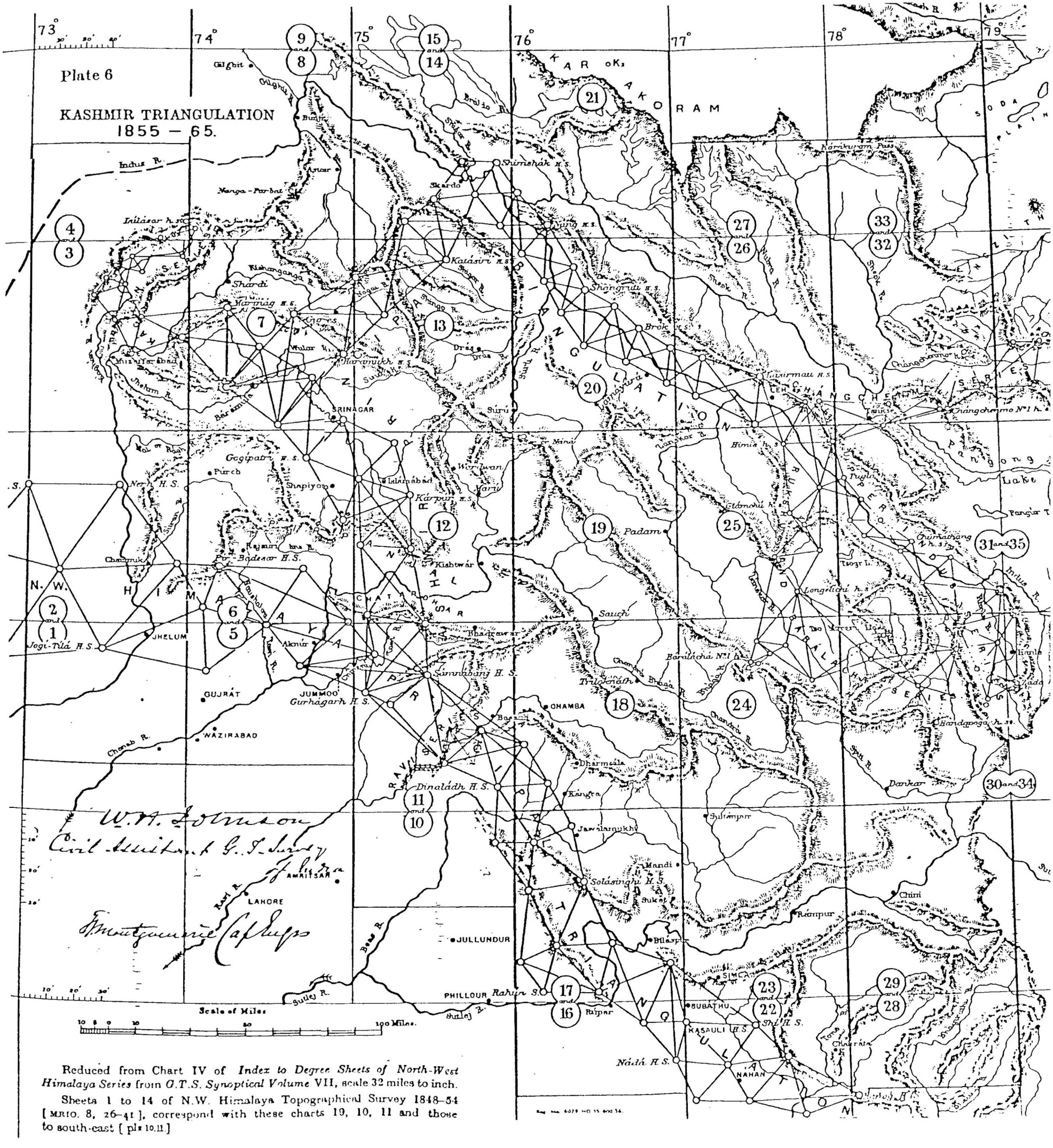
Regarding the occupation of Trikota mountain as a station of observation, ... you will spare no effort to carry out the series independent of that sacred mountain but, if after every exertion your endeavour should fail, you will then to try to obtain the consent of the parties interested on the spot and of the Maharajah. ... Force must on no account be resorted to, but everything should be done in the most conciliatory manner. ... His Highness the Maharaja Goolab Singh is well known to be friendly...towards the Survey, and no opposition need be apprehended except from subordinate authorities. ... Very little work remains to be done in the Jummoo territory, and every exertion should be made to traverse it speedily[7].

In his report of November 1850 Logan records that the party arrived at Samba on the 9th, Gurhagurh on the 11th, ... Mr. Logan and Mr. James [W.R.N.] proceeding towards Trikota mountain, at the foot of which they arrived on the afternoon of the 16th. ... The mountain...appearing unsuited for a station—both owing to the expense of road construction...and the dislike which the inhabitants...entertain to having a... survey station on it—notwithstanding the permission given by Maharaja Goolab Singh—it

[1] DDn. 606 (79), Du Vernet to SG. 4-6-50. [2] DDn. 542 (37), SG. to Mil. Dept. 28-8-50. [3] ib. (75), SG. to Bd. of Admin. 4-9-50. [4] Keelan, Mulheran, Chas. Olliver, Blewitt, John Dyer, Johnson, Talbot, E. Dyer, Summers, *GTS.* III (vii—C). [5] had continued as Chendwar Series whilst on the NE. Longl. [16–17, 361]. [6] DDn. 542 (37), SG. to Mil. Dept. 20-8-50. [7] DDn. 499 (374), SG. to Logan, 27-9-50.

Plate 6

KASHMIR TRIANGULATION
1855 – 65.



Reduced from Chart IV of *Index to Degree Sheets of North-West Himalaya Series* from *G.T.S. Synoptical Volume* VII, scale 32 miles to inch.

Sheets 1 to 14 of N.W. Himalaya Topographical Survey 1848–54 [MRTO. 8, 26–41], correspond with these charts 19, 10, 11 and those to south-east [pls 10.11.]

INDEX TO THE DEGREE SHEETS OF THE NORTH WEST HIMALAYA SERIES



SON, PHOTO.

C. G. OLLENBACH, ZINCO.

Photozincographed at the Office of the Superintendent, Great Trigonometrical Survey, Dehra Dun, April 1876.

was determined to abandon the intention of retaining it as a station, and to select in its stead the hill of Tarakote situated immediately to the south of it. ...

Unfortunately Tarakote was not visible from Samnabanj. ... Mr. Logan proceeded to visit the Siraoli mountain, and arrived at the summit [8177 ft.]...on the 23rd, but had hardly observed the bearings...before a violent snowstorm occurred, which in a few hours covered the hill with several inches of snow. ... Siraoli could not be used as a station from the middle of December to the middle of March owing to the immense quantity of snow which remains upon it [222]. ... It was with...difficulty that a party of hillmen were induced to ascend the mountain on the 25th November in search of seven men of Mr. Logan's party who had lost their way down on the 23rd, even when the snow on the hill did not exceed six inches[1].

It was eventually decided to abandon the line along these higher hills, and to follow one "along the lower range of hills and partly along the undulating country at the foot of the hills in which there are several elevated mounds, the sites of old villages"[2]. Observations were commenced in January, and completed up to the Jhelum by the end of the season besides secondary triangles to fix Siālkot and Jammu, and peaks of the Pir Panjāl. Minor triangulation was carried down the Rāvi and across the Bāri *doāb* by Hennessey to make junction with Keelan's work on the Beās, and to supply data for revenue surveys[3] [118, 273, 296].

During season 1851–2 Logan brought the principal triangles forward from Jogi-Tila, one of the peaks of the Salt Range, to close in the Chach valley east of the Indus, but he was not able to get the view to Nanga Parbat that the Surveyor General had hoped for [86][4]. William James took the approximate series up to the Indus, marked out a line for the Chach base, and then laid out the first two figures of the Great Indus series [44 ; pls. 3, 5, 7]. He then ran a secondary series to Peshāwar ;

On the completion of the work at Chach, Mr. James was directed to proceed southward for...selecting the stations for a series of principal triangles to be eventually extended down the river Indus. ... After selecting five stations, Mr. James...proceeded to Attock to commence the Peshawar series. This...was undertaken for...connecting Lieutenant Walker's Peshawar survey with the general operations of the Great Trigonometrical Survey, as well as for determining accurately the position of Peshawar itself [215–6].

The survey was commenced on the 27th February, and although the weather immediately became exceedingly unfavourable...the series was completed on the 9th of April[5].

James was escorted by a troop of the Guides which he left to guard his signallers at Takht-i-bhai near the Swāt border, whilst he moved to his next station. A party of Swāt tribesmen surrounded the hill and, being at first mistaken for the return of James himself, were able to get into the camp, and were only driven off after a sharp struggle and several casualties[6] [475].

Logan completed observations up to Chach by January 1852, and then observed the first two polygons of the Great Indus series that were urgently required for Robinson's topographical survey [210–1]. For season 1852–3 the party was shifted to the Rahun series near Ludhiāna [50], and the following season, 1853–4, joined in the measurement of the Chach base-line [40–1].

GREAT LONGITUDINAL, 1848–53

In October 1848 Renny-Tailyour marched the old Maluncha party from Dehra Dūn to start the Great Longitudinal series from Sironj to form the southern limit of the north-west grid of triangulation. This series was to follow parallel 24° in extension of the Calcutta Longitudinal, and to close on a base-line to be measured at Karāchi[7]. The party included a young military officer Alexander Strange who had spent one season with the North-West Himālaya series, and two experienced assistants, Lane and William Rossenrode, the latter taking the important task of laying out the triangles in advance.

[1] Kashmir Series broke out from this side Gurhagarh-Samnabanj [222, pl. 6]. [2] DDn. 503 (176) 1–12–50. [3] Assts.: Wm. & John James, Hennessey, Carty. [4] DDn. 591 (112–4), 31–12–51. [5] 10 triangles with 14-inch theodolite ; DDn. 610 (88), Logan to SG., 27–7–52. [6] *GTS.* III & *Syn.* I (xxv–vi—D). [7] *GTS.* I (12) ; III (iii–xiii—B) & *Syn.* II (iii, i–148—B).

The series being of particular importance [2, 98] was like the North-West longitudinal to be laid out in quadrilaterals and polygons, and angles were to be observed with Troughton & Simms' 3-foot theodolite. Certain small defects found in the theodolite at the first stations were put right by Strange [150].

Renny completed observations at 13 principal stations between January and May 1849, before he was stopped by thick weather[1]. Rossenrode carried the approximate series a full 200 miles, covering the junction with the Khānpisura series of the Bombay triangulation [55–6][2]. Rivers joined up with his party for several months, and assisted mainly on secondary triangles and topographical sketching which the Surveyor General had specially asked for[3] [51, 120–2, 391–3].

After spending the rains at Nimach Renny was called up to Dehra Dūn, leaving Strange in charge from 6th September 1849[4].

During season 1849–50 Strange advanced westwards through south Rājputāna, observing at 18 principal stations, with four azimuths, and making good junction with the several meridional series of the Bombay triangulation. By the beginning of March the atmosphere had become so thick with dust haze that, after waiting six days without seeing any signals, he closed fieldwork, much to Waugh's indignation [366]. Rossenrode carried on till 10th April, by which time he advanced the approximate series to about 30 miles beyond Abu, at which station the whole party assembled for the rains [99].

This southern area of Rājputāna is a rough country, running through the native states subject to Seronj, Gwalior, and Holkar. To the west of Neemuch the nature of the country is more formidable, and the series enters a wild uncivilized land whose rugged hills and dense jungles are the abode of the Bheel and Meha tribes with whom it is very difficult to deal on amicable relations. Villages are here thinly scattered, cultivation meagre, and provisions consequently dear and scarce. These characteristics become aggravated as the series proceeds over the Arabulli range of mountains, to cross which, even by the high road, is a work of difficulty [362, 467]. ... The unfrequented mountain passes, contracted by rocks and overhung by dense jungle, afford passage but for a single man.

Beyond Mount Aboo the difficulties...will be of another and often of more formidable character, ... being a complete desert[5].

Strange wrote fully of all his difficulties ;

Having been 16 years in the country I am not without experience of travelling in India, having traversed in several directions the entire Madras Presidency, besides proceeding by land...from Trichinopoly to Simla, ... and...no country so difficult...have I ever seen or heard described. The Himalaya, of which...I have some knowledge, present no difficulties to be compared with the very peculiar tract through which my work at present lies.

He went on to press for increased allowances for himself and his staff but failed to win much sympathy from the Surveyor General [99–100, 453][6].

During season 1850–1 he took his triangles some sixty miles through these rough hills working from Mount Abu first along his northern stations, and then back along the southern flank. He completed observations at 24 principal stations, with reciprocal vertical angles at ten of them and astronomical azimuths at four. The cantonments of Deesa and Erinpura, and the cities of Siroli and Udaipur were fixed by secondary triangles[7].

His greatest difficulty was the transport of the great theodolite from one rocky hill-top to another [362]. At the highest point of Mount Abu, he had the satisfaction of seeing the great theodolite arrive safely at the station. ... The united efforts of 35 men were required for the box containing the body of the instrument alone, instead of its usual complement of 16 men, and its progress even with this large number was slow and laborious. ... Provided the width of the road be sufficient to afford firm footing to the men, and that good steady bearers be under the poles, almost any degree of steepness, ruggedness, and irregularity may be surmounted by the aid of additional men hauling on ropes and supporting the bearers. ... The instrument on several occasions safely surmounted the most abrupt and broken acclivities, some of which...must have presented an angle of not less than 40°.

[1] with azimuths at 3 stations. [2] DDn. 462 (358), Report 1848–9, 1–9–49. [3] *IO Cat.* (258, 266), Route srvys. by James Fraser between ors. Stns. [4] asstS.; Lane, Rossenrode, Pierce, Burt. [5] DDn. 542 (37), SG. to Mil. Dept. 20–8–50. [6] DDn. 708 (81), 23–10–50. [7] DDn. 542 (24), Report 1850–1, 28–1–51.

He devised a form of harness by which the great box was suspended from two stout bamboo poles with the bottom of the box slung more than three feet above the ground, and yet secured from turning or slipping ;

Had not this, or some analogous plan, been adopted, the instrument could never have been carried up my hill stations. ... Making good roads would have cost...enormous sums of money, ...whilst...an inferior instrument would have depreciated the character of the work. ...

Bad as the Arabulli country is, its difficulty...is much enhanced by the unwillingness of the inhabitants to...[carry] loads. ... I...should certainly have been very seriously delayed but for the services of a native officer of the Meywar Bheel Corps, ... Subadar Chuttur Tewaree. ... Having been long...employed in recruiting from the Bheel population...his influence with them was extraordinary. A word from him sufficed to collect strong gangs of carriers when no persuasion from anyone else was listened to[1] [117].

Rossenrode made a rapid reconnaissance of the desert to within 50 miles of Tatta [99–100 ; pl. 1] and found it

a vast arid tract...scanty in villages, which are for the most part small and poor, ... at great distances from one another, and...chiefly inhabited by cattle graziers, ... [with] no means of provisioning a party of the survey. ... I should suggest that suitable depots for such provisions be established at the centre of each polygon for duly furnishing the surrounding...stations.

Water is indifferent, and in some places decidedly bad and unwholesome. Where it does exist is chiefly by artificial means, as in small tanks and ponds in which people collect rain-water. There are also some katcha wells from 20 to 40 feet, and pucka wells from 100 to 150 feet below the surface, generally containing a depth of water from 2 to 4 feet. When at any place these sources...become exhausted...the few families of the locality migrate to some more favoured spot.

The desert consists of a vast undulating, wavy, sandy tract, abounding in ridges and low sandhills varying in height from 60 to 80 feet[2]. Some of these seem permanent from...having their sides covered with vegetation, and would prove of great value as trigonometrical stations, ... requiring a superstructure of only 6 to 15 feet, and the expense of these towers may be somewhat diminished by occasionally cutting rays across the tops of a few of the sand ridges. ...

Bricks will in most cases be made close to the stations from clay, ... but the water for constructing them, and building, ... will in many instances [come]...from 5 to 10 miles in camel pakals. ... Lime can only be procured at [x] and [y], and the expense...will be greatly enhanced owing to its requiring camel carriage. ...

All travellers use camels, and men on foot can with difficulty accomplish a long march, not only on account of the nature of the sand, but owing to the scarcity of water, combined with a nut-shaped thorn with long spikes or spears...to be found through the whole extent of the desert thickly strewn on the soil and on the grass which produces it. To avoid this thorn the inhabitants wear leather stockings. ...

Workmen and labourers must be obtained from a distance, and employed on regular monthly pay to assist in building the towers, and in fact to render every aid hitherto obtained from coolies, masons, carpenters, and others temporarily hired. ...

On the whole the expense will be far less than might have been anticipated[3].

Rossenrode's hopes were justified, and he was able to lay out his approximate series of polygons and quadrilaterals without any artificial construction other than masonry pillars sufficient to take the feet of the great theodolite.

The approximate series has been extended by Mr. Rossenrode [writes Strange]...nearly half across the desert, a distance of about 145 miles, attaining the longitude of 73° 15′, and comprising one double hexagon, three single hexagons, and four quadrilaterals, formed by 31 principal stations [99] ... From Aboo to the borders of the Rann the country is a very difficult one for selecting stations, consisting...of long and gentle undulations of nearly equal elevation, and clothed with jungle from 12 to 20 feet high. ...

For several months, owing to the negligence of the Deesa dak, his communication with me was virtually severed. It was uncertain whether or not towers would be required, and if required how materials were to be obtained. ... I could only...leave it to his discretion[4].

Strange completed his observations across the desert in the one season, 1851–2 ;

Sucess depended chiefly on traversing the desert at the best season. ... The best season being very brief, not more perhaps than three months in duration, it was necessary that the rate of my progress should be very much more rapid than...customary. ...

[1] DDn. 615 (51), Strange to SG., 21-5-51. [2] A grand view can now be had on flight between Delhi and Karāchi. [3] DDn. 708 (92), Rossenrode to Strange, 30-1-50. [4] DDn. 615 (51), 21-5-51.

I therefore applied all my resources to the task of reaching the fertile plains of Scinde in one very brief season. ... The object was fully attained, the triangulation of about 3 degrees of longitude with the allotted number of observed azimuths, viz., 9, having been completed in the space of 3 months and ten days.

He made careful provision for transport providing a full forty camels for water and supplies ;

The greater portion of these camels were employed in establishing two depots of grain obtained at Deesa, ... each depot containing 20 days supply. The camels were then employed in keeping the camp and the detached signal men and secondary party supplied with provisions. Each signal party was allowed one camel loaded with grain. Mr. Rossenrode had 8 camels, and Mr. McGill[1] the same number. The rest were constantly engaged in carrying grain and fetching water for the main camp.

Additional porters were required for the great theodolite ;

The number usually allowed would not suffice to carry the instrument long marches over the deep sandy country. It was one of my principal rules this season to make but one march from station to station. ... I never deviated from it. ... I thought the circumstances justified my entertaining eight additional bearers.

The desert crossed was the southern part of the Great Indian Desert locally known as *thar* [or *thal*, 7, 47], and often termed "The Little Desert" ;

The popular idea of a desert is that of a boundless and barren level plain of loose sand, arid and scorched, and unmarked by any fixed habitation of man. The "Little Desert" differs widely from this. It is throughout composed of sandhills, whose general form is that of a long straight ridge with a conical transverse section. These ridges seldom unite, but stand at close and regular intervals, generally lying in the same direction. The ripple mark on the sea shore affords a fair illustration. ... Some of these sandhills are perhaps a mile long, and they vary from 50 to about 300 feet in height. Their sides are deeply channelled by the rain. ... These sandhills are evidently permanent.

There is more jungle than might be expected, ... but it is low and almost leafless. There are no trees. The whole desert in the cold season is clothed with grass attaining a height in many parts of two feet. It is at that period much resorted to as a pasture land by owners of large herds of cattle, by whom, however, it is deserted on the approach of the hot weather.

The permanent population is, of course, scanty. ... Villages are scattered at intervals of from 8 to 12 miles, and consist of a few conical huts, scarcely a man's height, and rudely constructed of twigs and grass. A few camels and a well comprise the wealth of the village. No cultivation is attempted except during the rains, when an uncertain crop of bajree is obtained[2].

A fine race of men inhabit this inhospitable region, athletic, ... independent, cheerful and civil. Intelligent and brave, they only require to abstain from their favourite pursuit of cattle-stealing to rank above almost any other natives of India. ...

Travelling in the desert is exceedingly laborious to men carrying loads. No sooner is one sandhill passed than another presents itself. Their sides are very steep, and every frequented track is converted into deep loose sand into which the feet sink to the ankle. No carts are used, nor are loads ever carried voluntarily by the inhabitants otherwise than on camels. ...

The air in the desert in the cold months is very transparent, nor did I witness any...mirage [65]. On the whole I consider the "Little Desert" to be a tract favourable to our operations.

The transition from the desert to the plains of Scinde is surprisingly sudden. In the space of a hundred yards the traveller leaves sand and sandhills, and enters a perfectly flat country with a firm black loamy soil. Inhabitants, customs, language, and vegetation, are exchanged with the same startling abruptness. That part of Scinde reached...this year is...perfectly flat—the soil is hard, black, and devoid of grass—jungle is plentiful and thick.

The country is populous and cultivated, and it is intersected...by irrigating canals dry in the cold season. Such a country is...a very unfavourable one to us[3].

A few of the stations along the southern flank lay in the Rann of Cutch, where conditions were difficult, and mirage frequent [58]. The Rann was found in November to be superficially dry,

the soil of a dark colour, totally without vegetation, and in many places so smooth as to reflect the image of the sun like water. The soil, however, becomes dry to the depth of an inch or two only, and this crust being removed a soft quagmire strongly impregnated with salt is discovered, from which abundance of vapour constantly arises.

[1] James Hamilton [431]. [2] *bajra* = an Indian Grain, *pencillaris spicata*. [3] *GTS*. 615 (195), Strange to SG., report, 1851-2, 7-4-52.

In the rains the Runn is entirely flooded by rain and sea-water combined which. on evaporating, leaves the salt...covering the surface of the depressed portions[1].

In January 1852 Strange took two months leave, handing over charge to Lane, who observed one more hexagon, and then marched the party back from the neighbourhood of Umarkot to recess at Abu. During this short season of less than 3½ months observations were made at 39 stations over a direct distance of 180 miles, with astronomical azimuths at seven of them.

For season 1852–3, the last of four spent on this Great Longitudinal series, Strange had the assistance of James Tennant who had joined at Abu in March 1852. They started out on 15th November ;

Sickness still prevailed, ... and my camp suffered very considerably. ... Regular marching had no doubt a beneficial effect, but I was so unfortunate as to lose by death four men. ...

I marched straight across the desert to my station of Adoori in the plains of Scinde, which point I reached on the 8th December. ... The angles...were taken there last season by Mr. C. Lane. He took the usual precaution of establishing four outside marks 90° apart as points by which to examine the permanence of the station centre [106]. ... The towers of both Adoori and Khori had inclined. At Adoori I was able to place the instrument over the true centre, but at Khori the deviation (4·95 inches) was too large. ... The amount, therefore, of the deviation and its azimuth were duly noted and all angles have been corrected. ...

Work progressed smoothly but—owing to...grazing rays—...slowly, until we reached the station of Chootlee. Here a melancholy detention occurred. ... The side Chootlee to Helaya ...is 22 miles in length. At Chootlee there is a tower of 37 feet ; Helaya is on a very low hill. The Indus crosses the ray about two miles to the eastward of Helaya. More than half the ray was obstructed by very dense babool jungle[2], and it was crossed in several places by sheets of water which caused considerable difficulty in...clearing. ... Thick dust was constantly rising from the bed of the Indus. The side was...altogether an improper one.

They were held up here 25 days, getting only occasional faint glimpses of the heliotrope and generally finding the lamp quite invisible. At the next station there was trouble with the tower ;

The tindal reported that lumps of earth were falling from the tower, and that it emitted a crackling sound. Finding this true we immediately packed up the instrument and struck the observatory tent. At about 7 o'clock that evening one angle of the tower fell. ...

Next day we made endeavours to dislodge the other angle with small blasts of gunpowder, but without success. I determined therefore to depute Mr. Lane the task of having the upper portion of the tower pulled down carefully. ... He was instructed to raise a ramp around the tower extending up two-thirds of its height, and to rebuild the remaining third as usual.

The masonry pillar appeared quite sound. The accident was owing partly to the height of the tower (39 feet), and partly to bad workmanship. All my towers in Scinde are constructed of alternative layers of wood and earth. The wood should be substantial, and the earth should be wetted. In this case both these conditions were neglected [111][3].

Regarding the grazing ray the Surveyor General commented ;

The difficulties...from a long grazing ray crossing a great river show how desirable it is in selecting stations to avoid, if practicable, rays not clearly visible at maximum, for although observations may be obtained to faint lights, ... there can be doubt that the angles so obtained must be inferior. ... Mr. Rossenrode's experience hardly requires this...to be impressed on him. In 117 stations there appears to have been only one which gave extremely difficult rays, and the configuration of the country, I suppose, rendered it unavoidable[4].

Rossenrode's contribution to the success of the longitudinal series had been most important ; with sound judgement and great energy he had taken the approximate series from Sironj to Karāchi a distance of nearly 700 miles in four working seasons, having selected no fewer than 113 principal stations, only two or three of them having to be shifted later. To him also fell the responsibility for the erection of tower stations and for deciding their heights : he selected a site for the base-line at Karāchi[5]. During season 1852–3 he started laying out the Great Indus series.

During season 1852–3, also, secondary triangulation was carried out by Lane to fix the positions of Hyderābād, Kotri, and Jherak, besides the port of Sonmiāni. Other towns and Manora lighthouse were fixed from the principal stations.

[1] *GTS.* III (xi—B). [2] *babul* = *acacia*. [3] DDn. 618 (53), Report 1852–3, 9–7–53. [4] DDn. 591 (330), SG. to Strange, 29–7–53. [5] for these services granted a special increase of pay [408].

There were incidents during the last stages across and beyond the Indus to the hills above Karāchi. The constant dust rising from the river bed necessitated the use of blue lights. At one station Strange had sent both to Hyderabad and Kurrachee for a further supply. ... Before the blue lights arrived our constant watching was rewarded by one of those gleams of extraordinarily clear weather that are of such rare occurrence in the plains at this season. The lamp became visible for the first time, and though so faint as to strain the eye most painfully, we were able to obtain... a very satisfactory value of the angle required. ...

My next station was Ghatana. On the evening of the 13th April between 9 to 10 o'clock a storm of wind came on which I have never seen equalled. ... Fortunately a number of men were near the station and, inspired by the tindal's energy, they managed with the greatest difficulty, though about 50 in number, to keep the tent from being precipitated upon the instrument. On reaching the hilltop I was thrown to the ground by the strength of the wind, for the hill lay isolated in the wide plain exposed to all its fury. So imminent did the danger appear that I at once commenced dismantling the instrument. I got the telescope safely into its box, and when all was clear I made the tindal and another trustworthy man help me lift the instrument off its stand and carry it outside the tent.

There was no time to put on the lifting irons; we placed our hands underneath the foot-screws. We succeeded in depositing it on the ground clear of the tent, and though this was done in total darkness, and in the midst of a deafening uproar, ... no injury whatever was inflicted on the great theodolite.

The weather which had been for some time unfavourable became after the storm very clear, and our observations now proceeded satisfactorily. Fortune favoured us. Finishing... in a wild uninhabited tract, we at length reached our goal, Nuggur Peer hill station, where on the evening of the 22nd April the last angle...was taken, and the work successfully brought to a close[1].

Whilst Strange was completing his last triangles, Tennant cleared the base-line site—"every bush rooted up—level observations taken...twice over...to determine its longitudinal section"[2]. It fell to Tennant also to make the tidal observations at Manora required for adjusting the heights of the longitudinal series and for the start of the spirit-levelling [74, 76].

Strange handed over charge to Tennant on 20th October 1853, and joined the Surveyor General's office at Dehra Dūn, with a view to taking part in the measurement of the base-line at Chach [43, 158]. The designation of the party was now changed to the Great Indus Series, and that of the longitudinal series to the more specific Karāchi Longitudinal Series[3].

The Surveyor General was disappointed to find that there was a discrepancy of about ten inches between the length of the Karāchi base as measured on the ground and as brought up from Sironj by triangulation, a discrepancy he attributed to uneven settlement of some of the towers[4] at the Indus crossing and in lower Sind [106, 109].

BASE-LINES; CHACH, 1853–4

The Chach base-line was measured between December 1853 and February 1854 at the junction of the North-West Himālaya and the Great Indus series. The west end of the base falls just 8 miles east of Attock Fort [pls. 5, 7][5].

The site was first selected by William James of Logan's triangulation party in October 1851, and approved by the Surveyor General on his visit to Peshāwar two months later. The line was not actually measured until two years later when Logan's party marched up from Dehra bringing the measuring apparatus together with two heavy stone pillars to serve as mark-stones, and Barrow's great 3-ft. theodolite for use on the connecting triangles[6]. John James of Robinson's party was deputed to clear the line in October 1853; "as soon as the 20 feet space is

[1] DDn. 618 (53), Report for 1852–3, 9-7-53. [2] DDn. 618 (53), 9-7-53. [3] *GTS. Syn.*, III. [4] DDn. 594 (231–3) SG. to Tennant & reply, 22–6 & 2–7–55. [5] *GTS.* I, vi, (2–31); *Syn.* I, Gt. Indus Ser. chart I. [6] DDn. 543 (75), 12–5–53.

marked off we may expect the villagers to use it as a road, which will do much good and should be encouraged[1]".

The Surveyor General himself took charge of the measurement, for which he assembled several of his most experienced surveyors, Logan, who had been on the Dehra Dūn base-line in 1834–5, Strange, Walker, Keelan, Mulheran, Montgomerie, and several juniors who had not yet seen the elaborate apparatus[2].

Mr. Logan, having ably assisted in the measurement of five previous base-lines, was the most experienced officer at my disposal. ... Owing to the retirement of Major Renny-Tailyour, Mr. Logan and myself were the only officers in the department acquainted with the use...of the base-line apparatus. The employment of himself and his party...was a matter of absolute necessity [20]. The party marched from Dehra in October 1853 along with my headquarters, and arrived...early in December when the measurement...commenced. It was successfully terminated under my immediate...superintendence in February 1854, after which the party was engaged in packing and transporting the apparatus to Karachi[3].

The base-line was 7·83 miles long, on an azimuth of 234° 41′. It was divided into four sections that were verified by minor triangulation, which with the connection to the main triangles was carried out by Montgomerie with Barrow's theodolite [150]. The first set of comparisons with standard bar A [IV, 47] was made on 6th December and the last on 22nd February. On 6th January a violent earthquake rocked the stone pillars and disturbed the levels[4].

Logan's party was then detailed to march the apparatus down to Karāchi. His health broke down on the march to Lahore, and he died at Mussoorie three months later. Keelan took over charge and his march

from Lahore to Karrachee during the months of April, May, and June, ... with an establishment composed *chiefly of men* to whom the very name of Sind is obnoxious [452][5], was an achievement reflecting great credit on that valuable assistant. After suffering great hardships, exposure, and privations, the party...reached Karachi in safety[6]] 50, 158, 371].

After the measurement of the base the Surveyor General was asked to advise on a site for "an iron suspension bridge across the Indus below Attock, and Strange was deputed to make an accurate measurement of the span at the chosen site[7], being "delayed a few days...whilst preparing my boat for a voyage down the Indus to Karachi". He and Mulheran laid out a short base of 903 feet by wooden rods set out at right angles to the river, and connected by minor triangulation "to the site of the bridge in the gorge below Attock". The job was completed between 28th February and 2nd March [337][8].

BASE-LINES; KARĀCHI, 1854–5

The site for the Karāchi base-line was chosen by Rossenrode during season 1851–2 [41][9], "a fine spot of ground free from nullahs, ravines, and rivers", its south-east end being about 8 miles north-east from the church, and four miles from the sea-coast[10].

After closing observation of the longitudinal series, Strange erected stone pillars at the two ends of the base, these being truncated pyramids about five feet high and weighing more than 20 maunds each[11]. Leaving Tennant in charge, he then joined the Surveyor General for the measurement of the base-line at Chach. He returned to Karāchi on 1st June and took charge of the 2nd Hill Series and the base-line apparatus which Keelan had brought down in bullock carts by road [*sup*]. As bullock carts are not used in Sind, these had to be kept on for the return journey, the apparatus being too precious to be shipped by the steamboats which were then running between Karāchi and Multān [IV, 476 ; V, 77][12].

[1] DDn. 588 (132–4), SG. to Robinson, 5–8–53. [2] Wm. James, Hennessey, Geo. Shelverton, Belletty, Johnson & Carty. [3] DDn. 643 (19), SG.'s Report on 2nd Hill Series. [4] *GTS.* I, VII (2–30); IV (vi–2); *Syn.* I (64). [5] but Waugh later rejected Shortrede's account of this dislike [391]. [6] v. n.3, *sup.* [7] on behalf of Crommelin, Engr. in ch. [8] Mulheran's report, DDn. 609 (109, 117) 5–3–54; Waugh MSS. II (ix); Attock rlwy. bridge built 1882. [9] DDn. 701 (160), SG.'s instructions *GTS.* I/VII (1–30). [10] DDn. 615 (195), Strange to SG., 7–4–52. [11] as used at Sonakhoda [20]. [12] DDn. 618 (116), Strange to SG., 27–9–53; 611 (73), Aug. 1854; 612 (61), 8–7–54.

After spending the rains of 1854 at Mussoorie Waugh travelled down the Sutlej from Ferozepur which he reached on the morning of November 1st ;

I embarked immediately and got under weigh at noon of the same date. A favourable voyage to Tatta at this season is reckoned at 25 days from Ferozepore, ... but the boatmen say it entirely depends on the wind. ... My camp requires 34 camels, and that number are in fact now proceeding by land to Karachi to be ready for the return journey. In the meantime we shall require equivalent carriage to transport the camp from Tatta to the base-line. If 10 or 11 of the base-line carts are available they would suffice, ... otherwise as many as can be spared, the difference being made up by hired camels.

The Mathematical Instrument Maker, Sayed Mohsin, is proceeding to Karachi, and will be at your disposal from the date of his arrival [from Calcutta by sea].

For the march from Tatta to the base-line camp "the strength of my camp is—military officers, 2[1]—civilian, 1—native Establishment, 100—Guard ; havildar, 1, naicks, 2, sepoys 16—camp followers, 60—horses and ponies", 4[2].

The party assembled at Karāchi comprised four military officers, Strange, Tennant, Nasmyth, and Montgomerie, and seven assistants, Lane, Keelan, Belletty, Burt, Carty, Smith and McGill, besides Mohsin Husain from Calcutta. Waugh himself was delayed at Mithankot by sickness, but he sent Montgomerie on with the necessary fieldbooks, including a copy of the Chach measurements as guide.

After completing all preparatory work Strange started actual measurement on 6th December, the day that Waugh arrived. All went well ;

Lieutenant Colonel Waugh desires...to acknowledge the satisfactory manner in which the Major has carried out...instructions, ... and the ingenuity he has displayed in effecting mechanical alterations in the way of improvement or convenience[3].

The base-line was 7·32 miles long, and as usual was divided into four sections. The first comparisons were made on 30th November 1954 and the last on 29th January. On conclusion of the measurement Strange went ahead to join the headquarter office at Dehra Dūn, whilst Lane and Keelan marched up with the apparatus and the establishment of the 2nd Hill Series. Tennant remained at Karāchi with the Great Indus series, made the final connections with the tide-gauge at Manora, and took astronomical observations for latitude [130–1][4].

Waugh later compiled a special report on the measurement of base-lines[5] ;

I have treated of the subject...at great length, entering into a discussion of the merit of the apparatus, and of the relative results of the measurement of the seven great Indian bases with the same apparatus[6]. I have also taken this opportunity to place on record memoranda of instructions, chiefly drawn up by myself, ... for the information and guidance of my officers. ...

By these...I have furnished...a complete practical guide for using the apparatus to the best advantage. A specification has also been added of an apparatus which, in my humble opinion, would be a great improvement on that invented by General Colby[7] [158–9].

GREAT INDUS SERIES, 1852–6[8]

As in the case of the North-East Longitudinal series, the Indus series was carried out by different parties and different surveyors as opportunity presented. Work was spread over nine seasons.

Start was made from the north early in 1852 when two polygons were completed from Attock to Kālābāgh by Logan's 2nd Hill Series [37]. The country was open with commanding hills, and progress was easy and uneventful. The immediate needs of Robinson's topographical party having been thus provided for, Logan's party was shifted to Rahun after recessing at Dehra Dūn [50].

For the line from the south the Surveyor General wrote to Strange in 1852 :

It is my intention to carry a great series from the Karachi base to the Attock, or Chuch base. This work stands next in importance to the Great Longitudinal series, and as the

[1] Waugh & Montgomerie. [2] DDn. 592 (139), SG. to Strange 6–11–54. [3] DDn. 709 (112), DO. 22–1–55 ; 643 (19), Report 2nd Hill Ser. 1854–5. [4] Inset & Chart I, *GTS. Syn.* I, Gt. Indus Ser. [5] Waugh Mss. II. [6] Calcutta, Dehra Dūn, Sironj, Bidar, Sonakhoda, Chach, Karāchi. [7] DDn. 643 (214), & 665 (438), SG. to Mil. Dept. & DSG., 11–5–58. [8] *GTS.* III (1–211—D) ; *Syn.*, I (iii–iv—D) wrongly gives 1853 for obsn. Attock to Kālābāgh.

length is very great, I propose...to employ two parties working from each extremity...until they form a junction. ...

As this is essentially a frontier series, ... the best arrangement...is to carry the principal series as near the boundary line as political circumstances will admit or physical circumstances render desirable. ... Discretion may be allowed if the following conditions are born in mind.

Keep as near the western frontier as practicable. ... The course to be as direct as...the frontier will allow, so that the number of triangles may be a minimum. ...

The series will have the advantage of hills for 1½ degrees of latitude, as far as the Manchur Lake near Sehwan [pl. 3], and thus far...may be double, i.e., consisting of polygons or quadrilaterals. ... But beyond this hilly tract, the operations will enter into a flat cultivated tract, in which, ... to secure expedition, it will be necessary to adopt a simple series of single triangles. ... This Great Indus series will furnish for the Punjab data for referring to the level of the sea, and...too much care cannot be taken in observing vertical angles[1].

During seasons 1852 to 1854 Rossenrode carried the approximate series some 450 miles north from Karāchi to a point above Mithankot beyond the Sind boundary[2], but considerable changes had to be made later [48; pls. 1, 3].

Season 1853–4, Tennant carried observations through the hilly country north of Karāchi, working up to "the latitude of Sehwan through a perfectly deserted tract by means of 12 principal stations".

The passes in the hills were very difficult, and excepting with hill camels none of them could have been overcome. These animals are very skilful in picking their way among the large rounded stones in the river beds, and in climbing the steep broken passes by going down on their knees. No ordinary camels could have ascended Myher Hill[3] which resembled somewhat a staircase in part. The camels had to be changed more than once as the extreme difficulty of the tract prevented them from lasting more than a few marches. ...

Water was in many cases distant and difficult of access; ... the total absence of rain in the hills during the preceding season had left the usually small amount of water smaller still. ...

At Sulimani...on the 26th of January we had a severe storm and heavy rain...and till the end of the month the weather was unsettled so that no observations could be satisfactorily taken. On the 27th a puckal of water was frozen solid during the night. ... In the observations at this place...nearly the whole month of February was spent.

Early in March further advance was prevented by cloud and mist and the lack of water for signal men. Tennant now marched north towards Lārkāna, but further observation was impossible and at the end of April he returned to Karāchi.

On the way to Sojra I ascertained that each successive station in the hills would have been impracticable, and also that Maru Pir tower was in so delapidated a state that it was unfit for use[4]. On reaching Sojra I found that water was not to be had nearer than a march from B—, J—, and Ding, which agreed with Mr. Rossenrode's account, though I was assured that the same rain we had at Sulimani had filled tanks close to the stations.

The puckals[5] purchased at Karachi were of inferior quality, and having been out by the stones and torn by thorns in the hills were not fit to carry water to such a distance. ...

I received information that a party of Brohis[6] had mischievously destroyed the heliotropes and lamp at Jangarharna T.S. ... This appears to have been a mere accident caused by the Brohis finding a defenceless lamp-party at the station, and not a premeditated attack. ... The series should never have approached so near the frontier. I could only have sent a naick's guard, and as this would have entailed additional carriage for water and provisions, it would hardly have been justifiable where I had no reason to anticipate violence. One heliotrope and the lamp having been thrown down the tower in their boxes are capable of repair, but the second heliotrope is totally destroyed, having been...battered by the men's sticks.

He decided to abandon Rossenrode's line along the border hills, and his assistant Burt laid out a new line of short-sided triangles with a number of tower stations across the plains to the north [110].

Next season...I propose sending out no approximate party as the operations are now so far ahead. It will, however, be necessary to detach a sub-assistant to build the towers. I propose also...keeping a party permanently detached for secondary operations. ... I have been in correspondence with Major Jacob who has requested me to lay down some points which will... connect his triangulation with ours [78 n.2, 279].

[1] DDn. 709 (1), 26–7–52. [2] Rossenrode now transferred to Coast series [27]. [3] Maihar HS.; 50 m. N. of Karāchi. [4] Sojra, 30 m. W. of Lārkāna; Maru Pir TS., 30 m. further S. [5] water bags or cans. [6] Brahuis, a Baluchi tribe.

With respect to...th e River Indus, I would recommend an abandonment of all intention of carrying a chain of triangles along the banks. The course of the stream is liable to changes of from four to six miles in a single year. ... All the station marks will be in constant danger from the floods unless the sides be made much longer than could be overcome without high towers[1].

After return to Karāchi Tennant was engaged on tidal and astronomical observations, and the measurement of the base-line, and did not resume triangulation till November 1855 [74, 130]. The Surveyor General had accepted his recommendation to revise Rossenrode's lay-out, both to avoid the tribal frontier and to facilitate observations ;

I quite agree with you as to the advantage of having sides short enough to secure distinct vision and steady signals without resorting to lofty towers. ... At 10 miles with adequate towers signals may be distinctly seen in all weathers and seasons, but the distinctness and steadiness rapidly decreases for every mile additional. It is now my usual plan to design a series in the plains with an average length of side equivalent to 11 miles, in order that no side may be less than 9 miles nor more than 13 [101]. ...

For 12 miles towers of 24 feet at least are necessary unless mounds are available. ... If the sites, however, are not favourable, ... towers of 30 feet will be necessary. ...

I have no hesitation in sanctioning any alteration in Mr. Rossenrode's approximate series which you may deem necessary. ... Considering the reputation which that assistant had acquired...I was unwilling to believe that any part of a series selected by him required to be rejected. ... I can sympathise with your anxiety to make sure of having favourable signals. ...

Mr. Lane informs me that crossing the Indus at Sukkur the series enters at once a low inundation tract extending half way to Bhawalpore. The east flank of the series is likely to fall on the edge of the desert where low sandhills abound favouring the work, but necessitating short sides because heavy towers cannot be founded on sandhills[2].

For season 1855–6 Tennant was given a fresh staff of assistants[3] with whom he completed the principal triangulation through the hills, and extended into the plains of Lārkhāna.

We left Karachi on the 6th November and, marching by the river on which road, water, and provisions are plentiful, I reached Bhit H.S.[4], on the 1st December. We had much sickness on the road which rendered the party very weak, and before leaving Sehwan we had all felt the effects of the proximity of the river, even at that late period. ... Messrs. Armstrong and Dyer joined me...about Christmas, and from the 1st of January I detached Mr. Dyer to superintend building and ray-clearing. ...

I have...succeeded in identifying a large number of well-defined points...from the hill stations, and...in the plains I took the opportunity of laying down all the rejected stations of Mr. W. Rossenrode. ... I detached Mr. J. W. Armstrong to carry a chain of triangles from my series towards Jakar ; Mr. Rossenrode's rejected tower stations were employed. ... Mr. Armstrong also succeeded in determining three points of Colonel Jacob's triangulation. ...

Meanwhile I carried on the principal triangulation. ... I was latterly much hindered by misty days and rain, so that at last I despaired of completing the Laka hexagon[5] in time for the party to reach Dehra before the setting in of the rains. A burst of comparatively fair weather, however, enabled me to do so, and I completed it at Chandia Khan T.S. on the 7th April, and reached Sakar on the 4th of that month.

At Sakar Mr. Armstrong rejoined me, having...like myself suffered from the weather, ... and here I also found Mr. Smith whom I had detached...to bring up the astronomical apparatus from Karachi. ... Only one station now remains to complete the double polygon in advance of my closing figure, and two more stations will make a heptagon having a side along the river from Sakar to Adu Shah's Garhi[6].

As the immediate requirements of the Sind Government had now been met, Tennant's party was shifted to the Jogi-Tila series to relieve Walker who was to extend the Indus series southwards from Kālābāgh. He handed over charge of his stations near Shikārpur to the local authorities, and on 4th April proceeded direct to Dehra, leaving Armstrong to march the party up from Sukkur, a journey of over two months[7].

[1] DDn. 593 (467), Tennant's Report for 1853–4, 15–5–54. [2] DDn. 592 (182), SG. to Tennant, 8–6–55. [3] Armstrong, Belletty, J. Smith, Wm. Dyer. [4] 30 m. W. by S. from Sehwan. [5] Jakar, 10 m., Laka, 20 m., W. of Lārkhāna ; Chandia Khān, 18 m. NW. [6] figure surrounding Shikārpur; DDn. 692 (163), Report for 1855–6, 19–7–56. [7] arrd. Dehra Dūn, 21–6–56.

During 1856 to meet the needs of the revenue survey of the Derajāt to the west of the Indus [217–8] the Surveyor General moved Walker's party from Jogi-Tila to resume work on the northern section of the Indus series, replacing it by Tennant's party from Upper Sind [46, 53] ;

The only way in which the triangulation can reach the Derajat expeditiously is by working the series...down the valley...from Kalabag, reversing the present arrangement of bringing it upwards from Sukkur. The...most efficient arrangement...will be to entrust the duty to the party...located nearest Kalabag. This party is...under the orders of Lieutenant Walker. ...

That officer is intimately acquainted with the Derajat, ... having conducted the Peshawar frontier survey [214–7]. ... I propose employing the party...hitherto designated the Jogi-Tila series on the Great Indus series, and transferring the party under Lieutenant Tennant to...continue the former [361][1].

Walker took the field in October with four civil assistants[2]. As the plains lying between the Indus and the Sulaimāni Mountains to the west are too narrow to permit of a double series without risk of attacks from border tribes and those on the east form the sandy wastes of the Sind-Sāgar *doāb* [274–5], it was decided to carry triangulation down the river with one flank on either bank, until it could be conveniently brought over to the right bank ;

It was decided to place one flank...in the Sind-Saugur Doab and the other in the Derajat. The sandy plateau, or thull, of the doab is higher than the lowlands near the river. ... The edge of the thull stands like a perpendicular wall over the lowlands, looking across the river into the Derajat distant 9 or 10 miles [52]. ... The line thus chosen has the advantage of taking the series through the most populated districts, of giving trigonometrical stations to the revenue surveys on both banks, ... and of being the most direct line for...a symmetrical junction with the triangles in Scinde.

Stations were selected as far south as Dera Fatteh Khan [pl. 1], ... one large double polygon partly in the hills and partly in the plains, and two quadrilaterals and two polygons wholly in the plains. A large cairn of stones was also erected on the summit of the Takht-i-Sooliman to serve as a secondary station [pls. 1, 3]. ...

The hill stations were first visited, commencing with Shekh Boodin where, as well as at Maidan, ... the observations were taken with Troughton & Simms 24-inch theodolite No. 2. ... The great theodolite [TS. 3 ft.] was considered too valuable to risk [151].

Maidān is on the Marwat range which runs along the right bank of the Indus, forming the boundary between the present districts of Bannu and Miānwāli.

The obstacles to our having a station on the range...were solely of a political nature. The range is inhabited by the Baruk branch of the tribe of Khuttucks. ... Occupying the wildest and most intricate hills in the Kohat District, they are in a measure isolated from the rest of the tribe, among whom they bear a noted character for thieving, being said even to have plundered Affreedies. ...

To pay them a casual visit was easy enough, but to station a party of Hindustani signallers among them for some weeks, and to get them to allow a road for the great theodolite to be made to the summit of their hills, ... were delicate and difficult tasks. ... The Deputy Commissioner... sanctioned the attempt, and Lieut. Walker went to the village of Maidan near the summit of the range to select the station. Mirza Sajjad [215, 447–8], being familiar with...Pashtoo, was directed to make the road, and after a few days talking—the headmen...having collected—he succeeded in calming their apprehensions and obtaining their co-operation[3].

A number of mountain peaks were fixed, ... of which five are on the Sufed Koh range, thus determining its outline with accuracy[4] [IV, 278 ; V, pl. 2].

Lieutenant Basevi had started early in the season from...Dehra Doon, ... bringing with him the great theodolite [TS. 3-ft.]. ... He only arrived in time to assist in the selection of the stations of the last polygon. This being his first season in the field, he was instructed in observing with the great theodolite. ... Finally, he was entrusted with the sole conduct of the principal observations while Lieut. Walker proceeded down the Indus to reconnoitre[5].

By the end of the first season, 1856–7, triangulation had been completed from the neighbourhood of Kālābāgh to that of Dera Ismail Khān, whilst the approxi-

[1] DDn. 643 (77), SG. to Mil. Dept. July 1856 ; 619 (302), DO., 8–8–56. [2] Belletty, Carty, Edw. & Alex. Donnelly. [3] the Khattack villagers were most friendly when I obsd. at Maidān H.S. in 1905 to start a Tochi series. RHF. [4] east-west boundary between Tirah & Afghānistān ; Sitarām, peak 15,620 ft. [5] DDn. 722 (514), Report 1856–7, 9–12–57 ; *GTS.* III & *Syn.*, I (v–vi, xxvii–viii—D).

mate series extended another 50 miles further south to Dera Fateh Khān. Distant peaks had been fixed in the heart of Waziristān.

The party withdrew for recess at Murree, already an established hill station for military convalescents and families, and Basevi joined Montgomerie in Kashmir. On the outbreak of the mutiny in May, Walker at once volunteered for military service, but returned in September on medical certificate [482]. As he could not take the field before December, Basevi took the party out in October. Since the valley of the Indus was the safest and quietest part of the Punjab, and the country to the east was still seriously disturbed, the Jogi-Tila party was transferred to the southern section of the Indus series under charge of Armstrong [53][1]. Walker held general charge of the whole series for the next four years.

As sufficient military escorts were not available during 1857–8 it was considered unwise to risk the great theodolites, so the work of both sections was restricted to secondary work, and to the selection of stations, line-clearing, and erection of towers and platforms. In the 400 miles between Dera Ismail Khān and Shikārpur there were to be 117 principal stations, of which only one was on a hill and five on mounds left by ruined forts or villages. All the remainder required the construction of towers ranging from 15 to 40 feet in height. Walker discusses at length the best line for the main triangles ;

The northern portion on the approximate series has been carried down the Indus by Lieutenant Walker as far as Dehra Futtikhan. The southern portion has been brought up the river as far as Mithunkote by Mr. Rossenrode. The upper section may be considered final, but the lower section was executed some years since. Many of the station marks are probably lost... and the work is known to have been executed very hurriedly. Consequently it must all be done over again [45][2].

The eventual direction of the series, whether it is to be carried wholly on the east or on the west bank, ... or partly on both banks, can only be decided by a reconnaissance of the ground between Mithankote and Sukkur, which should be undertaken before the approximate series is continued below Dehra Ghazi Khan. As far as that station...the series should be conducted on both banks as in the northern portion already completed. ...

From an inspection of the maps of Captain Johnstone, Surveyor of the Derajat [218], ... there is much probability that the series may be conducted over the west bank. If so, we can effect a symmetrical junction with Lieutenant Tennant's triangulation by fewer triangles. ...

The proper line...can only be determined by a reconnaissance on which...I propose to set out. ... Mr. Armstrong...will probably not reach Sukkur before the 1st of January, by which date I might reach Mithankote. A month should suffice to enable me to decide[3].

By the end of season 1857–8 the 400 miles gap in the approximate series had been closed to about 90 miles. Line-clearing through the thick *babul* and tamarisk jungles in the riverain areas of Upper Sind had been particularly arduous.

During season 1858–9 Walker had four separate parties working under him—Basevi observed the principal triangles at the northern end—Keelan the same at the southern end—Armstrong closed the central gap in the approximate series—whilst Walker himself ran a line of spirit levels from Upper Sind to Karāchi. This independent levelling was introduced as a check against the regular vertical angles of the triangulation that were liable to serious errors over the long stretches of closely grazing rays [3, 62, 76–80].

Walker writes to the Surveyor General in December 1858 ;

The great cause of delay...is the enormous number of towers which have to be built, many of them...being in out-of-the-way places where labourers are only to be provided by collecting them...from villages which are several miles from the point where the tower has to be built.

From...where Mr. Armstrong commenced his approximate operations last year to Dera Futti Khan, where Lt. Basevi commenced his, is a distance of about 350 miles, and involves upwards of 95 principal stations. Of these one only will be a hill station[4], and at the very utmost not more than nine...platform stations. ...

In designing the southern section...last season I availed myself as much as possible of the towers which had been built both by Lt. Tennant and Mr. Rossenrode. ... We have thus ready

[1] Tennant having reverted to military duty. [2] DDn. 722 (404), Walker to SG., Oct. 1857. [3] DDn. 710 (183), Walker to SG., 28–10–57. [4] Nazir-da-posht HS., 10 m. N. of Kashmor [pl. 1].

to hand...four of Lt. Tennant's towers, ... five of Mr. Rossenrode's, ... of which three have been in a great measure rebuilt, and six towers built by Mr. Armstrong de novo during the recess. This gives us 15 stations ready to hand in this section, and Mr. Armstrong hopes to build 15 more during the present season [110–1]. ...

Throughout the whole distance of 450 miles between the hills of the southern and those of the northern section, nine-tenths of the stations will...be towers of more than average height, and built with more than ordinary difficulty.

I expect Lieut. Basevi will execute 100 miles of...triangulation this season which will bring him within 30 miles of Dera Ghazi Khan. ... If Mr. Keelan succeeds in reaching Kusmore... there will still remain a gap...of about 160 miles, which will tax the utmost exertions of the two complete parties to finish in one season. To secure this, ... Mr. Keelan should quarter either at Mithankote or Dera Ghazee Khan to carry on the tower building during the recess, and be near the ground for resuming operations next season. ... During next recess Mr. Armstrong should join Lieut. Basevi and assist him in bringing up his computations[1].

By April 1859 Basevi advanced the northern section nearly 100 miles, having to rebuild four of his towers, and being frequently delayed in obtaining boats for crossing and recrossing the river. He was finally brought to a stop by overtaking his approximate series, and Belletty had to remain in the field for several more months to press on tower construction.

Keelan also advanced the southern section about 100 miles, bringing his final observations up to Kashmor, on the northern border of Sind about 60 miles south of Mithankot. Again progress was much delayed by line-cutting, and he calculated that it took 44 Baluchis ten days to clear a line of 13 miles, and that there were more than 20 such lines to clear or reclear. Making his headquarters at Mithankot he then carried on the approximate series right through the hot weather.

By March 1860 he closed his observations from the south in the neighbourhood of Mithankot. Work had been delayed as several of his towers and material for construction had been swept away by the annual river floods, and after these had been rebuilt observations were impeded by the annual burning of the dense grass jungle. He then marched his party back to Dehra Dūn.

By the end of season 1859–60 Basevi had completed observations on the northern section and connected with Keelan's triangles. During his short absence with a military expedition against the Mahsūd Wazīrs [217, 219], his assistants were engaged on secondary work connecting Multān and other important points[2].

Thus the Indus series, double throughout its length of 747 miles, was at last brought to a satisfactory conclusion. Over 400 miles had fallen through dead flat country where sides of triangles had to be kept short with a corresponding increase in the number of observations to be taken. The lengths of the other three chains enclosing the north-west quadrilateral were—Great Arc, Sironj to Dehra Dūn, 425 miles—North-West Himālaya, 408—Great Longitudinal, 672 miles[3].

In an attempt to rectify a comparatively large closing error, the younger Thuillier and Herschel who had worked one season under Basevi in 1859–60 were deputed in October 1860 to revise with theodolite TS. 3-ft. certain triangles that had originally been observed with the 24-inch. Walker started them near Kālābāgh and then accompanied them to Mithankot by boat where further revision was carried out. After completing this revision Herschel took up the new Sutlej series near Mithankot[4] [53].

INTERIOR SERIES; RAHŪN 1852–3, 1855–7, 1860–3

The interior chains of triangles of the North-West Quadrilateral commenced under Waugh's direction included—from east to west—the Rahun, the Gurhagarh, the Jogi-Tila meridional series, each named from a station of the North-West

[1] DDn. 710 (235), Walker to SG., 6–12–58. [2] *GTS. Syn.* I (xxviii–ix–D): DDn. 710 (308), Report 1859–60, 5–6–60 (21). [3] *GTS.* IV & *Syn.*, I (xii—D); Waugh Mss. II (o), 8–8–60. [4] *GTS.* IV & *Syn.* (iii—H); *GR. Trig.* 1861–2 (3–4), OBO. Comp., M–9–7; Walker to SG., 26–11–60.

Himālaya longitudinal. There was also the Sutlej series which followed that river from its junction with the Indus on the south-west to its meeting with the Gurhagarh south of Ferozepur [pls. 3, 5].

Starting from the neighbourhood of Dharmsāla in Kāngra, the Rahun Series ran south through Ludhiāna, Hissār, and Jaipur, to close on the Great Longitudinal near Kotah. It was started in 1852 to provide trigonometrical control for the revenue survey of the cis-Sutlej States and the Rohtak Canal engineers [269, 272][1].

Logan had recently completed the North-West Himālaya longitudinal, and the two northern figures of the Great Indus series [37]. On reaching Rahun station[2], on 22nd October 1852, he found that the mark-stone had been removed, so commenced work from two hill stations to the north. Whilst Keelan selected stations in advance, the rest of the party built towers and cleared rays[3]. After two months illness Logan took up the final observations at the end of January and by mid-April had completed 25 principal triangles[4]. Several secondary and minor series of triangles were run by Armstrong and other assistants to survey the main rivers and lay down marks for the revenue surveys.

After spending the next season on the Chach base-line the party, still the 2nd Hill Series, marched down to Karāchi with the measuring apparatus, dropping Logan at Lahore, desperately ill [43]. After assisting at the Karāchi base line during field season 1854–5, it resumed the Rahun series in October 1855, this time under Charles Lane[5].

Lane took up work from Logan's last stations to the west of Patiāla, and work proceeded smoothly. Towers of from 20 to 40 feet were constructed, generally on sandy mounds composed of the ruins of old villages, and requiring deep foundations. During 1856 Lane was transferred to Assam, handing over charge to Keelan, who carried his triangles down to the hilly country near Alwar. On return to Mussoorie in April 1857 the party passed through Delhi and Meerut only a few days before the outbreak of the mutiny. The country south-west of Delhi was so disturbed that during season 1857–8 the party was employed on recess duties at Mussoorie, and in October 1858 was transferred under Tennant's charge to the Gurhagarh series to the west[6], whilst Keelan took over charge of the southern section of the Indus series for the next three seasons [48, 110–1]. In 1860 Keelan marched his party back to Dehra Dūn [49], to resume work on the Rahun series.

> In 1857...I left four kalashies...in charge of these two stations...in the independent Rajpoot states, and of Khaira hill station...in the Jhujjur State [264], ... with instructions that the marks...were not to be disturbed or injured in any way. Shortly after the arrival of the party at headquarters the rebellion broke out and very soon extended to the Jujjur State where these men had been left, and who were never heard of again. ...
>
> Before proceeding with the approximate series, my first duty was to examine the...stations...to ascertain if they were disturbed, but I was glad to find both untouched. ... The pillars and marks...were found precisely as I left them in April 1857[7].

Proceeding south through Jaipur, the Rahun series, about 550 miles in length, was closed on the Great Longitudinal during season 1862–3, having taken six working seasons to complete[8].

GURHAGARH, 1847–9, 58–62

Gurhagarh hill station of the North-West Himālaya series lies to the east of Jammu city [pl. 6], and the meridional series follows fairly closely to meridian 75°, passing through Jullundur and the western parts of Hissār and Shekāwāti. From parallel 28° it then bends slightly west through Ajmer to absorb the Aramlia series which had been brought up by the Bombay party under Rivers for supplying geographical data for the revenue survey of Ajmer [56, 265–6][9].

[1] *GTS.* IV & *Syn.* V (1–106—E). [2] on citadel of Rahun town. [3] Assts.; Lieut. Montgomerie, Keelan, Wm. James, Johnson. [4] DDn. 593 (353), Report 1852–3, 27–5–53. [5] with Keelan and H. Beverley. [6] DDn. 564 (351), 6–10–60. [7] DDn. 692 (577), Keelan to SGTS., 26–8–61. [8] *GTS.* IV & *Syn.* V, series E. [9] *GTS.* IV & *Syn.*, IV (X—F).

According to my plan [writes the Surveyor General], he was to extend the Khanpisura series northwards from the parallel of Neemuch to that of Ajmere, conforming to the meridian of Aramlia. This triangulation, with the exception of an unsightly bend at the parallel of 25° 30′, has been ably carried out. It extends over two degrees of latitude, and consists of polygons containing 25 large triangles. ... Lieutenant Rivers...was intended to adhere to the meridian of Aramlia until he reached the parallel of Ajmer, and then to fix the position of revenue survey stations by minor triangulation [56]. A considerable quantity of secondary work has been performed, all towns of any size, hill forts, etc., laid down, as well as the cantonment of Nuseerabad. ... The Ajmere province was lately surveyed for revenue purposes [265–6], and the stations of that survey have been connected. ...

Mr. Sub-Assistant Fraser likewise completed a topographical map shewing every village, and the delineation of the ground in that portion of the Oodepore territory[1] [38].

This southern section was completed between 1847 and 1849.

The northern section was commenced in October 1858 by the party from the Rahun series which had been interrupted by the outbreak of the mutiny [50, 484]. Tennant was transferred from the Jogi-Tila series to take charge, and had to reorganize the party right through, there being a particular shortage of experienced *khalāsis*[2]. It was an unusually wet season ;

The first rain of the season fell...towards the end of December. ... We had already been delayed by rain in crossing the river, but it now came down in torrents. ... The outturn of January was in consequence very small and our fate in February was similar. We had few days without clouds, and generally heavy rain once or twice a week [52 n.5].

Of course the selection of stations did not suffer alone. The kutcha bricks were destroyed by thousands, ... and the moulders were discouraged. ... Thinking that my presence might be useful in urging the moulders and builders...I returned early in March along the rays, still accompanied by rain, till I reached Sialkot.

After testing the visibility of doubtful rays and reconstructing unsatisfactory towers, he succeeded in getting a few observations and closed down on 20th April ;

From Dehra station to Deoli T.S. my observations proceeded regularly. We had many interruptions from clouds and the wind at nights was very violent at times, with light rain. On the day of reaching Deoli, rain set in and was heavy that night and the next day. The tower (apparently of a very diliquescent earth) was unsafe ; large pieces were being constantly washed down, and our feet sunk into the earthen top. I therefore took down the instrument. Still heavy rain continued and injured the tower further so that repair was necessary before again putting up the theodolite. Reports too came in that the towers at Bhuru Chak and Langi had partly fallen, and that Atalgarh would require some repair[3].

In September 1859 Tennant was appointed Astronomer at Madras, and charge fell to George Shelverton from the Kashmir survey, who by 1862 completed junction with the Bombay work. He had considererable difficulty through the Rājputāna desert from shortage of drinking water and supplies, as well as material and labour for the building of towers [45, III] ;

Wholesome water was scarcely procurable, and...even for building purposes had frequently to be conveyed from distances of four and five miles. The larger reservoirs...upon which the inhabitants depended...during the greater part of the year had invariably been exhausted, and the expensive kucha wells of the country barely sufficed for local needs.

Connection was made by minor triangulation with earlier surveys and with places of importance. In one trip Donnelly "fixed the positions...of about 83 Bickaneer villages that had no existence in any of the maps". The total length of the series between one longitudinal series and the other came to 576 miles[4].

JOGI-TILA, 1853–7, 62–3

The Jogi-Tila series takes its name from a peak at the north-east end of the Salt Range which runs for many miles parallel to the Jhelum River. "On its summit there are two Hindu temples...and...various buildings...inhabited by the Jogis

[1] DDn. 502 (7), SG. to Mil. Dept., 20-8-50; Fraser's topo. chart, *IO Cat.* (258) [38 n.3]. [2] Assts., Chas. Shelverton, Clarke. [3] DDn. 695 (4), Tennant to SG., 7-6-59. [4] *GTS.* IV & *Syn.* IV (ix-x—F & 1-115).

who conduct the religious services. This peak was...a station of the North-West Himalayan triangulation".

The series runs south across the Chenāb and Rāvi rivers closely following meridian 73° 30′. It closes on a side of the Sutlej Series, and the extension across the Bikaner desert to the Great Longitudinal was abandoned. It straddles three *doābs*, the Jech, the Rechna, and the Bāri, each enclosed between two of the great rivers, Jhelum, Chenāb, Rāvi, and Beās, and it was largely to provide points for the revenue surveys of these *doābs*, and the maps compiled from them, that these meridional series were pushed forward [37, 273 ; pls. 3, 6].

Minor triangulation breaking out from the North-West Himālaya longitudinal was carried out during season 1852–3 by Armstrong who had brought his party up from the Hurilaong series in Bihār. He started in January 1853 "from Achnur in the territories of Maharāja Goolab Singh", working down the Chenāb to its junction with the Jhelum, and then up that river, erecting

small pillars of masonry, which would supply fixed points for the revenue surveys, and contribute to the accurate geography of the country. ... These junction marks are all complete in the south bank of the Chenab, and are of wood or brickwork according as the locality is affected by...the inundations of the river. ... In addition to the villages indicated in the plan, we have intersections to many temples and buildings, and many perambulated distances to villages which could not be inserted into the plan. ...

With reference to Major Shortrede, ... I had an interview with him...at Sialkote, and learnt...that his survey of the Sialkot District was nearly completed. ... He recommended me to connect the triple-junction village marks with my operations as the best means of incorporating the two surveys[1] [68, 273].

Armstrong completed his survey in May by closing on Jogi-Tila hill, having fixed the towns of Wazirābād, Jhelum, and Gujrāt, and innumerable village trijunctions[2]. In October 1853 he was deputed to start the lay-out of this Jogi-Tila series, sending half his establishment to work under Walker on the Chach base-line [43], and towards the end of the season Walker joined up with the full party. The series was arranged in a chain of short-sided polygons and the lay-out across these Punjab rivers and their *doābs* presented peculiar problems ;

The belt of ground lying in the immediate vicinity of each of the rivers, which is known as the khadir land—and usually has a breadth of five to fifteen miles including the mile or two of sand, shingle, and water, forming the river bed—is on a level which is a little above that of the river during the greater portion of the year, and below it during the summer months, when... the river then overflows the whole of the lowlands, and sometimes overtops the artificially raised sites of the villages. ...

Between the khadir lands of two rivers enclosing a *doab* there is always an elevated plateau—called the *bar*—which rises from 30 to 40 feet above the level of the khadir, ... forming a well-defined barrier to the lateral excursions of the river. ... The *bar* is covered with...stunted trees, scrub jungle, and low grass, ... inhabited only by migratory herdsmen who wander about with their cattle...where water is to be obtained [7, 39–40, 273]. ...

Great caution was necessary in the selection of...stations, more particularly. .[when] a station in a *khadir* land and one in the interior of the *bar* were...to be mutually visible[3].

From November 1854 Walker started to extend the approximate series to the south[4]. At the end of December he left Shelverton to carry on the reconnaissance, building of towers, and line-clearing, whilst he commenced observations from the north. Work was delayed by the usual dark and stormy weather of January[5], and there was an unfortunate hold-up at the first station in the plains.

Mutual visibility between it and the corresponding station of Hela, on the eastern flank. ... which had been constructed during the previous year, was impossible. ... Kothiala was situated in the *khadir* lands of the Jhelum River, Hela in those of the Chenab, ... and between them lay a breadth of about 13 miles of the elevated *bar*, which could neither be built over nor cut through excepting at enormous expense [47, 111].

It happened that a Hindu temple...was standing in the vicinity of the line, on the scarp of the *bar* towards Hela ; this temple—being a square building with a flat roof, and not very

[1] DDn. 597 (16), Armstrong to Logan, 4–4–53. [2] DDn. 597 (10-23); 547 (283), Jan.–Aug. 1853. [3] *GTS.* IV & *Syn.* VI (viii—G). [4] Asstts., Geo. Shelverton, Edw. Donnelly, Wm. Dyer. [5] known in Upper India as the Christmas Rains, or *chota barsāt* [51].

dissimilar in form from one of the survey towers when viewed at a distance—Mr. Armstrong had mistaken for the Hela tower. ... There was no alternative but to establish a station on the top of the temple in lieu of the one at Hela, though this necessitated the introduction of an angle...which very closely approached the minimum limit (30°).

Walker had to build a pillar on the top of the temple, construct a balance crane for hoisting the theodolite [IV, 125], and clear a new line through the jungle.

The selection of stations was particularly difficult with the general line running diagonally across successive *doābs* ;

The low level lands...interpose a...flat monotonous surface which is always inconvenient and difficult to span, being too wide for a single side of a triangle, too narrow to admit of two sides, and often requiring a hazardous extension over the high perpendicular ridge which usually separates the lowlands from the *bar*. ... Much embarrassment is also occasioned by the want of water in the *bar*. Mr. Shelverton was often compelled to sink wells varying from 40 to 110 feet as a preliminary to the construction of a tower station[1].

Frequent grazing rays brought trouble from refraction, and with reciprocal vertical observations impossible for lack of a second large theodolite, a number of stations were connected by spirit-levelling [65]. Work was closed towards the end of March owing to thick dust-laden atmosphere and recess was spent in Murree [48]. Walker then moved the party to the Great Indus series, and Tennant's party was brought up from Sukkur to take over Jogi-Tila [46–7].

During season 1856–7 Tennant had the assistance of Brownlow from the Kashmir survey, and the series was extended to the Sutlej. After a brief reconnaissance to the borders of Bahāwalpur where he met with some opposition, and after Armstrong had laid out a few triangles, Tennant reported that it would not be practicable to take the series across the desert to Abu.

Without subscribing implicitly to this opinion [writes the Surveyor General], I...confess that the difficulties likely to be encountered appear sufficiently great to warrant a special exploration by a flying party previous to an approximate series. This flying exploration, however, itself requires so many special arrangements for water and food that I think it should be deferred to more peaceable times.

The mutiny had yet to be quelled ; Tennant had been called up for military duty, and Armstrong was directed to move the party to the southern section of the Great Indus series [48][2].

The southernmost figure of the Jogi-Tila series is a hexagon astride the Sutlej making junction with the Sutlej series. The angles were observed by George Shelverton in field season 1862–3.

SUTLEJ SERIES, 1860–3

The Sutlej series was completed during three seasons, 1860 to 1863. It ran from the neighbourhood of Mithankot on the Indus and followed the left bank of the Sutlej River up to Ferozepur, connecting up the Indus, Jogi-Tila, and Gurhagarh series, and providing a basis for two additional meridional series that were carried across the great desert later[3].

It was carried out as a chain of single triangles, and observed with Troughton & Simms 3-foot theodolite[4]. Armstrong laid out the approximate series during seasons 1860–1 and 1861–2, whilst Herschel observed the final angles eastward to the Jogi-Tila series by April 1861. George Shelverton then completed observations to Ferozepur during season 1862–3 [pls. 3, 6].

During season 1860–1 Branfill ran a line of spirit-levels along the line. Where the towers were not ready for connection, stone bench-marks were fixed at distances of 10 to 12 miles apart for connection to the triangulation later on[5] [79].

[1] *GTS.* IV & *Syn.*, VI (ix, 1–65—G); cf. DDn. 722 (145–7), Walker to SG., 9–3–55. [2] DDn. 709 (369), SG. to Armstrong, 21–10–57. [3] Jodhpur and East Sind Merdl. [4] Herschel, Armstrong, Geo. Ryall, Trotter, J. T. Burt. [5] *GR Trig., 1862–3*, JTW. 1–9–63 (7); *GTS.* IV & *Syn.* VI (iii–vi, 1–60—H).

CHAPTER V

BOMBAY TRIANGULATION

Bombay Party — MERIDIONAL SERIES ; *Singhi, 1842–6, 60–1 — Khānpisura & Arāmlia, 1845–9 — Abu, 1850–2 — Kāthiāwār, 1851–62* — CUTCH COAST, *1853–7* — GUJARĀT LONGITUDINAL, *1851–2, 54—7, 60–1.*

THE Bombay trigonometrical survey had been placed under the professional orders of the Surveyor General in 1831 [IV, 72], and in 1838 the party had been absorbed into the Great Trigonometrical Survey [IV, 73–4 ; V, 101].

Harry Rivers of the Bombay Engineers had taken over charge from Jacob at the end of 1842, and held charge until he took furlough in 1853. He was followed in turn by Nasmyth and Haig, both also of Engineers. Of the assistants, Sanger and Da Costa were the mainstays ; John McGill replaced Fraser in 1851.

The Bombay Longitudinal series, started by Everest in 1822 from Bīdar on the Great Arc [III, 234–5], had been re-observed by Jacob and extended to the west coast. Rivers completed the South Konkan series, and by 1844 was in difficulty on the North Konkan, or Singhi, series. Leaving this unfinished on account of continued sickness and smoke-laden atmosphere, he switched to the Khānpisura series running north across the Deccan plateau. He then extended it, as the Arāmlia series, north to Ajmer, which he reached in 1850 [56].

Between 1850 and 1853, being joined by Nasmyth in December 1851, he ran a meridional series southward from Abu to Ahmadābād in Gujarāt, and then a longitudinal series westward into Kāthiāwār before taking furlough in March 1853.

Between 1853 and 1860 Nasmyth covered Kāthiāwār, Gujarāt, and Cutch with longitudinal and meridional chains. Three of these—the Gujarāt Longitudinal—the Cutch Coast—and the Kāthiāwār Meridional—were principal series of importance, that were supplemented by minor and secondary work. On 10th March 1860 Nasmyth handed over to Haig who finished off the work remaining in Gujarāt and Mālwa during the next two seasons.

Up till 1847 Rivers worked with a 15-inch theodolite by Dollond, and from 1848 with a good 18-inch instrument[1], which was used by the Bombay party until 1862 [155]. The Bombay work of this period, therefore, cannot compare with that carried out by the 3-ft. and 24-inch theodolites, though in acknowledging Nasmyth's work the Surveyor General notes that

> the quantity and quality of work achieved by his party with very inadequate means are truly wonderful. The whole tract...embraced by Kathyawar and Cutch has been fully triangulated and prepared for topographical survey. The numerous series into which this triangulation is divided close most satisfactorily, shewing extreme accuracy of observation, beyond what could have been expected from an 18-inch...instrument[2].

During 1862–3 Jacob's work on the eastern section of the Bombay Longitudinal was revised by Haig with a 24-inch theodolite [IV, 74].

MERIDIONAL SERIES ; SINGHI, 1842–6, 1860–1

During season 1842–3, whilst Da Costa was laying out the triangles of the South Konkan series that ran southwards down the Ghāts through Mahābaleshwar to

[1] TS. 18", No. 2. [2] DDn. 594 (361), SG.'s Report, 1859–50, 6–10–60.

the Goa border, Rivers had run the North Konkan, or Singhi, series northwards as far as Parnera near Damān[1]. Bad visibility forced him to leave many angles unobserved [IV, 75]. During the next season, 1843–4, whilst he observed the South Konkan himself, with connections to the sea-level [62, 72][2], Da Costa was deputed to carry forward the approximate series of Singhi beyond Surat, but

it is fatal...to enter the jungles of this neighbourhood before the end of February, and every party that has ever attempted to work here in the winter months has failed. Mr. Da Costa and his men...had not been in the Surat District three weeks before they were all without exception severely attacked by fever. Mr. Da Costa...became so crippled...that he had to move into Surat. By March he had sufficiently recovered to take the field again, and the jungles had now become fairly healthy, but the season of haze and smoke had recommenced, and nothing in the way of approximate work was feasible [460–1].

Returning from South Konkan in March, Rivers left immediately for Surat, hoping to observe the rays on which he had been foiled the previous season, but

the density of the atmosphere was just the same as when he was here before. He remained now three weeks, but never succeeded once in obtaining a glimpse of a single heliotrope. On April 9th he set out for Mahabaleshvar where he had established his headquarters[3].

In October 1844 Fraser and Sanger took up the extension beyond Surat, but lost a full month from persistent opposition by the inhabitants. It was said that the Māhārājah, or Gaickwar, of Baroda "was convinced that the two Englishmen were not traversing his dominions for the sole purpose of looking through a small telescope, and his inability to discover their ulterior designs greatly irritated him". It required a special reference to the Bombay Government to convince him that no evil was intended. By the end of the season the approximate series had been extended to the Narbada.

Rivers himself first went south to take an astronomical azimuth, and then returned to Parnera, but this time it was climate that defeated him.

So much was he delayed by illness and hampered by the number of sick, that the measurement of...six angles was all that he succeeded in doing throughout November and December. ... The fever as yet had shewn no signs of abating—the natives he had newly enrolled to replace those disabled by sickness had almost to a man succumbed to the disease—and several deaths had occurred. ... Every day brought the smoky season nearer.

He succeeded in completing observations to the south of the Narbada, but baulked of pursuing his work to the north he now extended his series into the high ground to the east, doubling his chain of triangles between Singhi and the Tāpti [pl. 3]. The Surveyor General considered this a waste of time, and directed him to abandon further work on the Singhi Series, and take up a new series on meridian 75° 30′ on the healthy Deccan plateau[4]. During season 1845–6 he found opportunity, however, on his way to and from his new work, to complete observation of a few angles of the Singhi series that had hitherto eluded him.

Work on the Singhi series now remained in abeyance for the next fifteen years till it was brought to conclusion during season 1860–1 by Haig, working southward from the Gujarāt Longitudinal series [61]. Haig's party again suffered heavy losses from fever and it was proved without doubt that it is fatal to enter the Rājpipla and Gujarāt jungles before February.

KHĀNPISURA & ARĀMLIA, 1845–9

The Khānpisura Meridional series broke out from the Bombay Longitudinal near Ahmadnagar, and followed meridian 75° 30′ northwards through Indore and Ujjain to close on the Great Longitudinal series near Nimach. Starting from the south at the end of 1845 Rivers brought it up to the neighbourhood of Mhow by April 1847, still working with the old 15-inch theodolite by Dollond.

[1] Singhi HS., 32 m. N. of Poona; Parnera on the coast 10 m. N. of Damān. [2] S. Konkan series completed by Haig, 1866–7, *GTS. Syn.*, XXIII (iv–vi—C). [3] *GTS.* XIV & *Syn.* XXIII (vii—H). [4] DDn. 462 (21), SG. to Mil. Dept., 19–8–46.

During season 1847–8 he took over charge of the approximate series himself in order to lay out a suitable junction with the longitudinal series from Sironj, with an extension of his meridional series northwards to provide points for the revenue survey at Ajmer [265–6]. Having reached latitude 25°, north of Chitor,[1] he started observations towards the south, but had failed to reach his work of the previous season when bad visibility and an accident to his theodolite compelled him to close down and march into Mhow ;

After dismounting the theodolite at the last...station, the box containing the vertical circle and telescope...was carried off by thieves during the night, notwithstanding that seven village watchmen were within ten yards. ... The box was found next morning about 150 yards distant from the camp, the only thing missing from it being the eye-piece [162][2].

The Surveyor General did not like this observation from front to rear ;

Final angles should never be commenced at the advanced end of a series and carried backward, because if any accident occurs the connection is thereby rendered incomplete, and the office duties of the series are thrown a year into arrears[3].

He ordered that for season 1848–9 Rivers and his party should assist on the Great Longitudinal series under Renny [38, 391–3] ;

The Surveyor General's attention having in September 1848 been attracted to the extreme wildness of Lieut. Rivers' observations, ... he was called on for an explanation. ... It appears that his instrument got out of order and had further been injured by the very unskilful means adopted by Lieut. Rivers to remedy the defects. ...

Lieut. Rivers...having apparently fallen into careless habits, there was no other course to follow but to order him and his party to join Captain Renny. ... By this means the Surveyor General obtained a more skilful report on the instrument, and Lieut. Rivers was afforded an opportunity of witnessing geodetical operations carried on in first rate style[4].

A new eye-piece reached Rivers in November 1848 in time for him to close the observations remaining on the Khānpisura series north of Mhow, after which he joined Renny on 5th March [38][5]. At the close of this field season he returned to recess quarters at Mhow. In October 1849 he marched north to Nīmach where he took over the 18-inch theodolite sent up for him from Dehra Dūn, and resumed work on the Arāmlia series to the north.

The graduation of this theodolite—one of those by Troughton & Simms brought out by Everest in 1830—was irregular, but Rivers found by experiment that he could get the best results by taking the means from observations on 12 zeros, and good results were thus obtained during the next 12 years.

He took the Arāmlia series up to Ajmer by a swing to the west, which the Surveyor General considered a blemish. He had intended, but had not specifically ordered, that the main series should have continued on the meridian of Nīmach, 75°, and connected to Ajmer by a minor series [51][6].

There were various delays. At the start Rivers found the platform of one of his stations of 1848 had been destroyed ; the site had to be shifted and all angles connected with it re-observed. During February he lost time from an arrow wound in the groin during an incident with some Bhīls [III, 440].

Towards the end of the season he re-observed the angles taken with the 15-inch theodolite in 1848, and tightened up his connection with the longitudinal series before moving into recess quarters at Nīmach[7]. The whole series northwards from the longitudinal series at Arāmlia was later incorporated into the Gurhagarh series after junction had been made at Ajmer in 1862 [50–1].

Rivers had left the Khānpisura series in the form of quadrilaterals and polygons, except at the break-out at the southern end, and this was remedied at the end of 1862 when Haig added a new station to complete a double polygon at the junction with the Bombay longitudinal. Later again all the vertical angles of the Khānpisura series were re-observed as the earlier heights were unsatisfactory [62][8].

[1] in Udaipur State. [2] *GTS.* IV & *Syn.*, IV (iv—F); *GTS.* XIV & *Syn.*, XXXI (vi—G); DDn. 518 (363), Rivers to SG., 30-6-48. [3] DDn. 325 (547–53), 13-9-48. [4] DDn. 462 (359), SG.'s Report on Khānpisura ser., 1-1-49; *GTS.* IV & *Syn.*, III (iv—B). [5] DDn. 325 (547–53), 13-9-48; 493 (66), to Renny, 16-9-48. [6] DDn. 542 (187). SG.'s Report 1849-50, 1-10-50. [7] DDn. 518 (432), Rivers to SG., 1-5-50. [8] *GTS.* XIV & *Syn.*, XXXI (iv—G).

The Abu meridional series running southwards from the Great Longitudinal to the neighbourhood of Ahmadābād in Gujarāt was planned to connect with sea-level at the head of the Gulf of Cambay and provide a check on the heights of the longitudinal series [67, 72]—to provide points for a topographical survey of Gujarāt and Kāthiāwār [191–2]—and then to extend south to meet the Singhi series [55][1]. None of these objectives was carried through [74].

In October 1850 Rivers took up the approximate series himself, but after the first polygon had been selected in the comparatively easy hill area, the country became very difficult. It was flat, broken by innumerable ravines, and covered with trees. Towers had to be built at every station. Neither Rivers nor his assistants had any experience of such work, and they wasted time in futile attempts to locate themselves by burning fires. Rivers was reluctant to try Everest's system of ray-tracing—slow but sure—and when he did the results were far from encouraging [60, 103]. Early in February he left his assistants to persist with the approximate series, and returned himself to make final observations from the north[2].

During season 1851–2 the series was brought to a close on a figure of the Gujarāt longitudinal near Ahmadābād and, to complete the connection to the sea, Da Costa laid out a minor series of triangles down to the mouth of the Sābarmati River, which he had to re-clear and adjust at the end of 1853 [72]. Nasmyth and McGill then spent six strenuous weeks searching for a suitable site for a tidal station [73] and completing observation of the minor triangles from the river mouth to Ahmadābād, some 70 miles.

> Surveying under a tropical sun, and up to the knees in mud and water must be harrassing at any time, but, unprovided with boats as we were, our duty...was irksome and...not free from danger. Mr. McGill on one occasion, and I myself on another, narrowly escaped being overtaken by the bore, while the circuitous route which the baggage had to take in order to cross the river left us on several occasions dependent on the hospitality of a miserable hamlet[3].

They were much troubled by vagaries of refraction [65];

> I have used heliotrope apertures of ½-inch, and lamp apertures of 2 inches. The signals, however, have seldom been the clear, sharp objects which short lines and small apertures suggest. Often in the southern portion of the series, where the lines crossed mud, alternately flooded and drying, the heliotropes resembled pillars of flame, while the lamps were large and unsteady. At other places from the flatness of the country the signals had all the disadvantages of grazing rays. At one time they were magnified and agitated by the air, and at another obscured by the dust of carts or cattle crossing the line.
>
> The vertical observations would suffer chiefly from these disadvantages, but I have endeavoured to ensure the accuracy...by repetition [63][4].

Though Nasmyth found what he thought a suitable site for a tide gauge, the sailors would have none of it. Connection to sea-level was made later at points along the south coast of Kāthiāwār [73–4]. Final connection of the Sābarmati series with Kāthiāwār triangulation was not completed till season 1860[5].

KĀTHIĀWĀR, 1851–62

From 1852 to 1862 triangulation of Kāthiāwār, Cutch, and Gujarāt proceeded with no definite programme. The main meridional series followed meridian 71°, north to the Great Longitudinal series and south to the island of Diu. Approximate work on the southern section was carried out by Da Costa during season 1852–3;

> The Portuguese authorities...were jealous of a British officer even landing on their island, and greatly objected to a tower being built and observed from. ... Rivers...explained to the Governor that his work was...purely in the interests of science, and had no military or political aspects. He also offered, if he were allowed to erect and visit a station at Diu, to give the

[1] DDn. 518 (480), Rivers' Report, 1850–1, 1–5–51. [2] *GTS.* XIV & *Syn.*, XXX (iii–viii—I). [3] DDn. 613 (124), Nasmyth to SG., 4–2–54; cf. 720 (23), Report for 1853–4; 693 (32–4), SG.'s Reports 1853–4–5. [4] DDn. 613 (125), Nasmyth to SG., 4–2–54. [5] *GTS.* XIV & *Syn.*, XXX (xiii–xv—K).

Portuguese the co-ordinates of their town, a gift...they do not seem to have valued, as his request was refused. He then wrote...to the...Bombay Government, through whose representations Mr. Da Costa was at length allowed to build the station of Dangarwani[1].

The following season Da Costa ran a minor series round the coast, starting from Gogha on the Gulf of Cambay in December 1853 and closing at Dwarka, the extreme north-west, by mid-June ;

The series extends the basis for the map of Kathiawar. Its execution has been well timed, for a survey of the coast is now being made by the naval authorities, and the value to the nautical surveyor of...Mr. Da Costa's triangles...is very great.

During season 1852–3, after re-arranging its junction with the Gujarāt longitudinal north of Wānkāner [pl. 1], Nasmyth completed observation of the meridional series to the sea-coast at Diu by the 10th of May, being delayed by having to rebuild some of the towers and by "cloudy weather, fogs, and storms".

The southern and south-western portion of the Kathiawar peninsula is known as the Gir. It is a wild, mountainous, and deserted tract, and its soil is poor, unproductive, and stony. The water is bad, causing dropsy and disease of the spleen [III, 127–8].

He then took a minor longitudinal series eastward to Gogha before withdrawing for recess at Rājkot.

In February 1854, after having first completed the Sābarmati series [57], he returned to the meridional series to lay out the principal triangles northwards across the Rann into Cutch.

He now met with a series of grievous delays. Hardly any of the rays were cleared, and on one of them—when he had spent much time in cutting down the trees—a village appeared in the way, and the tower had to be raised. ... He was overtaken by a violent storm, and after that till the last week of April...the air was seldom clear. ...

Since the time of our first crossing the Runn, the sea had gradually been extending over it, and where the water had lain for any length of time the mud was soft and there were in many places quicksands. Dead bullocks and stuck carts gave unanswerable evidence of the difficulty of crossing. The mud was such that my own camels, lightened of half their ordinary loads, did not get through it without accident. The water too in these places was particularly salt, and caused any lacerations made by the saline crystals...to smart severely[2].

Rivers had already reported on the difficulties of the Rann when laying out the Gujarāt Longitudinal series in 1851 [60 ; pls. 1, 3] ;

The large Runn opens into the sea at its extreme western end near the town of Luckput in Kutch, where there is a ferry to the Scinde side. The eastern part of the Runn diminishes to a narrow channel near Aungair in Kutch, beyond which it again expands and this smaller Runn opens into the sea...near Mallia in Kattywar.

In the fine weather the Runn is a plain of sand strongly impregnated with salt which hardens it so much that carts can cross it in any direction and without cutting it up much. The plain is so dead a level that after rain one may ride for miles through the water and experience no ...change in the depth. (The 9th N.I. marched once in August a distance of 12 miles without a dry step, and yet the water was never above the men's knees). On drying the salt crystalises, and the whole country is as white as snow till again broken up by the carts and cattle.

In the monsoon the rivers Loonee, Bunass, and Suraswattee falling into it cause the whole to be inundated to a depth of about 3 feet. Besides these the Nasa, a branch of the Indus, may be said to flow into the Runn ; it formerly passed Oomercote and Wanga Bazar and entered the sea near Sudhee. By the earthquake of 1819 Sudhee was submerged, it being now 3 feet under water. ... Since then the Ameers from hostile motives cut off its waters from where it leaves the Indus above Sukkur, and there has been no water in its channel since.

No fresh water is procurable in the actual Runn, but there are several islands in it, some of which are hills of about 200 feet high ; these are covered with good grass, and on them fresh water can occasionally be obtained.

The mirage is sometimes most extraordinary ; small ridges of a few inches high assuming the appearance of a lofty castellated town, and...a line of salt that of the ocean [40]. In fine weather when the plain is encrusted with salt, the heat and glare is almost unbearable by day, while in the cold months the temperature at nights is most piercingly cold [40, 65][3].

When he returned to observe at stations south of the Rann Nasmyth found the April weather fatal to health and progress.

[1] *GTS.* XXXIV (iv-xviii—J). [2] DDn. 613 (119), 17-9-53, 720 (23–5), Report 1853–4, c. July 1854.
[3] DDn. 613 (75), Rivers to SG., 7–8–51.

I had no option, however, but to persevere, for I expected that the towers, so hurriedly built, would be washed away by the rains. The winds were scorching, and the heat overpowering, and it was rarely that anything animate except ourselves was to be seen stirring during the heat in these days. Yet day would succeed day without one glimpse of either heliotrope or lamp to cheer our weary hours of anxious watching. ...

Excessive heat and bad water brought sickness in their train. Two cases of coup-de-soleil occurred, while there were no less than 14 of our number crippled with guinea-worm [II, 165]. The last week of April brought more agreeable weather. The observations in Kattyawar were completed, and the establishment crossed once more into Cutch[1].

The field season was closed in the middle of May, and the recess months spent partly at Māndvi and partly at Bhūj.

During season 1854–5 Nasmyth joined in the base measurement at Karāchi, leaving his assistants to extend minor and secondary triangulation and to make tidal connections at Miāni and Diu. At the end of December 1855 he carried the meridional series across the upper arm of the Rann to close on the Great Longitudinal north of Nagar Pārkar [pls. 1, 3].

Our visit...has been well timed, for the Runn between Beyla and Nugger Parker was dry. Had it not been so, there would have been difficulty in getting the instrument across, for the distance from shore to shore is 25½ miles, while from halting place to halting place the distance is probably not much under 40 miles. Had our visit been postponed later the difficulty would have been in seeing the signals. ...

At one of the stations of the Gt. Longl. Series a week's cloudy weather, during which there was partial rain, caused disappointing delay, and the detours which are forced upon us in order to get across the Runn at all diminish the resultant amount of work. The distance between Akoria and Warana is about 19 miles, yet to get from one station to another the establishment marched about 56 miles, and still had to wade through the soft yielding mud and water and sludge of the Runn[2].

Having completed the northern triangles early in May, Nasmyth spent the rains at Bhūj, leaving a gap to the south which he closed at the end of the year, when he found that several platforms and marks had been tampered with. He attributed triangular errors of over 3″ to an earthquake that occurred in November[3].

The meridional series was finally closed at Wānkāner on 21st December 1856.

CUTCH COAST, 1853–7

The Cutch Coast series breaks out from the Kāthiāwār Meridional near the head of the Rann, passes westwards through Cutch to Lakhpat, crosses the eastern mouths of the Indus, and then runs north through Sind to close on the Gt. Longitudinal near Tatta. It is over 200 miles long, a double series composed entirely of quadrilaterals and polygons.

The approximate series was started from the eastern end by Sanger during season 1853–4, and the break-out revised the following season by him and Da Costa. The whole party spent the rains of 1855 at Poona. For the return journey from Bombay to Māndvi, Nasmyth secured passages for himself and the instruments in a government steamer, but had to send Sanger, McGill, the *khalāsis*, and horses, by a country boat. There was a water scarcity at Bombay; the master was a poor navigator;

The wind was against them. ... With but little water left on board, he found himself at the mouth of the Persian Gulf within a short distance of Muscat. ... He sought to make some port on the Kattywar coast, but...the wind died away and there was no land in sight. ... A Bramin...was deputed to pray for better things, and...as morning broke...predicted a coming breeze...but it blew the wrong way. The Kattywar coast was passed unseen, and before the Konkan coast was gained the horses had been three days without water. ... A steamer hove in sight. A signal of distress was run to the masthead. ... The Captain of the steamer, having learnt that it was merely for water that he had been summoned out of his course, ... steamed away. ...

[1] DDn. 720 (23), Nasmyth's Report, 1853–4. [2] DDn. 720 (112), 1-2-56. [3] *GTS.* XIV & Syn. XXXIV (XV—J).

Having replenished their water supply from the Konkan coast, the party was at length landed safely at Mandvi on November 11th.

Nasmyth started work west of Bhūj, and spent the next two months revising the lay-out and observing. He then moved to complete the north section of the Kāthiāwār Meridional [59], whilst Da Costa carried the approximate triangles of the coast series due north up meridian 69° to close on the Great Longitudinal. As this line passed too close to the Rann, Nasmyth rejected it, and the next season, 1856–7, Da Costa and Sanger ran a new line parallel to the coast to cross the Indus to the west and join the longitudinal series just north of Tatta [pls. 1, 3]. It being impossible to work in the vicinity of the Rann till late March,

the two surveyors proceeded by boat to Karachi to recommence their work from its northern extremity. The new series started from the side Sahiji-Karothol, ... and after passing Tatta crossed a flat, damp, country, thickly overgrown. ... At first water was good and plentiful, but as the Rann was approached it became scarce and bad.

Having selected all the stations, Da Costa commenced building the towers near the Rann. During his stay in Karachi he had made arrangements for their construction, and had despatched material by boat to the north-west of Cutch, but...no workmen could be procured. ... At times it seemed as if the operations would fall through. ... Assistance...arrived from Mandvi.

The towers...were not easy to build, the foundations could not be dug two feet without water running in. ... A large supply of bricks had been prepared...but an unexpected fall of rain in February converted them into mud. ...

Towards the beginning of June the Indus overflowed its banks and flooded the whole country round, obliging Da Costa to return to recess quarters at Bhuj[1].

At the end of December 1856, Nasmyth resumed observations on the Coast Series, which he completed by the end of season 1857–8. To allow time for the construction of towers and clearing of rays across the west end of the Rann, Nasmyth worked from the Karāchi end, having to re-observe at several stations either because markstones had been destroyed [470], or because of refraction difficulties ;

On the Sind section...it was found impossible to take the vertical angles in the usual way. Many of the signals were not visible at the time of minimum refraction, and on approaching the Rann there were only a few that were so, and these were...unsteady. ... Nasmyth always observed at one extremity of every ray himself, while either Da Costa or McGill—equipped with a 12-inch theodolite—was at the other. By placing two assistants on this work Nasmyth was enabled to observe the vertical angles on two rays himself every day.

On one ray "the signals one day were not seen till 9 p.m. while another day they were visible at 7 o'clock in the morning"[2].

A considerable amount of minor triangulation was carried out in Cutch between 1856 and 1860, forming an almost complete network, and closely defining the coast-line.

GUJARĀT LONGITUDINAL, 1851–2, 54–7, 60–1

This series follows parallel 23° between meridians 71° and 75° 30′, connecting the Kāṭhiāwār, Abu, and Khānpisura meridional series. It traverses the plains of Kāthiāwār and Gujarāt on the west and the thickly wooded hills of the Pānch Mahāls and Mālwa to the east [pls. 1, 3].

Rivers started the section west from Ahmadābād in February 1852 whilst his assistants worked on the approximate series of the Abu meridional. The selection of stations westward to meridian 71° was entrusted to John Rossenrode who was posted to the party for the special purpose of helping with ray-traces [57, 103]. By the close of the season Rivers had observed the first seven triangles, the series being kept to a line of single triangles because "high towers were required at all the stations, and great numbers of valuable fruit trees had to be cut down on every ray" [24][3]. During the following season, after revising the lay-out of the final polygon of junction with the Kāthiāwār Meridional, Nasmyth assisted Rivers with the final observations which were completed by January 1853.

[1] *GTS.* xiv & *Syn.* xxxiii (iv–vi—L). [2] ib. xxxiv (vi–ix—L). [3] ib. xxx (iv—K).

Sanger started the approximate series eastward from Ahmadābād during season 1854–5, and this was continued by McGill during the next two years. During season 1860–1 Haig carried observations eastward from Ahmadābād to meridian 24°, and then worked south to connect with the Singhi Series [55]. The next season he extended the longitudinal series eastward to the Khānpisura meridian, completing the final observations by February 1862. He had particular difficulty in closing as two desirable stations of the Khānpisura Series were found to give no view to the west.

Kaula-ka-Mata, like Gumanpur, had been selected with regard to its own series only, and was situated on the roof of a temple, the spire of which intercepted all view from the west. It...became necessary to build a new station on the same hill, ... and to make the side Karsod-Indrawan the closing side[1]

Though in this instance the necessity for a westward connection could hardly have been foreseen, it is remarkable how often a first lay-out by the Bombay party was found unsatisfactory when the triangulator came to carry out final observations. Sometimes this was due to change of refraction from one season of the year to another, particularly in the flat country, but very often it was a case of failure to test every ray on the approximate series. Time and again the observer found that a selected ray was impossible owing to an intervening hill that entailed the selection of one or more new stations [102].

[1] *GTS.* XIV & *Syn.* (X—K).

CHAPTER VI

GEODETIC HEIGHTS

Vertical Angles — Refraction — Trigonometrical Heights — Spot Heights — TIDAL OBSERVATIONS ; *Bay of Bengal — West Coast* — SPIRIT LEVELLING.

THOUGH Everest realised the advantages of measuring vertical angles at the time of minimum refraction in the afternoon, he did not insist that this practice should be invariable, but strongly urged the taking of vertical angles by simultaneous reciprocal observations whenever possible [IV, 93].

Waugh fully accepted the fallibility of vertical angles, and constantly urged his surveyors to confine observation to the time of minimum refraction, and to make simultaneous reciproca lobservations. Where triangulation lay within reach of the coast, such as on the East Coast and South Konkan series, he insisted on frequent connection to mean sea-level [26, 71]. Where trouble was experienced from grazing rays, mirage, and other vagaries of refraction, he recommended the use of secondary intermediate stations and even the running of lines of levelling ;

Although atmospheric causes will always more or less preclude the attainment of extreme precision in the determination of heights trigonometrically, still I am confident that much might be done to improve our results. For example, whenever it is necessary for the sake of symmetry...to adopt grazing or nearly grazing rays, it would be best to determine the heights by intermediate supplementary points of secondary character, and if direct vertical observations are also observed on the grazing rays their results should only be used for contrast, and not allowed to bear on the final deductions. ...

As many cross rays should be established as possible, even although these may not be used in the principal triangulation. ... Vertical observations should be rigorously confined to the afternoon minimum and not taken to rising objects. ... Lamps will never be used[1].

He was far from satisfied with the vertical angles taken by the Bombay party, both under Jacob and Rivers ;

The heights...depend on single deductions except in four instances, and the results of these four...show how unsatisfactory the single deductions are. ... It is...a most indispensable condition to accuracy that no great length of time be suffered to elapse between the reciprocal observations. In resuming operations after a cessation of work it is always necessary to revisit the old points for...observing vertical angles, even should they...have been completed during the previous season, because the vertical angles of one season cannot be safely combined with those of another [64][2].

Owing to the large closing errors of heights, and the lack of reciprocal and check vertical angles, all vertical angles on the South Konkan and Khānpisura series were re-observed between 1882 and 1886 [56][3].

Waugh writes to Clarkson who was troubled by refraction over the Orissa swamps [65] ;

If simultaneous verticals cannot be taken, or if they fail to give satisfactory conclusions, the next alternative is to employ one or two intermediate and experimental stations, ... but when this method also is either impracticable, or fails of success, the only remaining alternative is levelling from tower to tower. ... The principle...consists in making the back and forward stations as nearly equally distant as practicable, and distance should never exceed 10 chains. ... Equality of distance ensures the refraction as well as curvature of the earth cancelling on the fore and back observations. Short distances render the refraction small, and enable you to read off the levelling staves with accuracy and precision [78]. ...

[1] DDn. 493 (66), SG. to Gt. Longl., 16-9-48. [2] DDn. 325 (403-6), SG. to Rivers, 4-5-46. [3] *GTS* XIII & *Syn.* XXIII (iv—C).

After the difference of level has been determined, either by simultaneous observations or by supplementary stations, or by levelling, you will have data for computing the verticals in vacuo. Consequently if you happen to have observed a single vertical at minimum at either end of a ray, a comparison of the two results will give the refraction very accurately. The conclusion thus obtained should be prominently noticed and commented on. From such data we may determine a rule for employing single verticals [64–6, 90][1].

As a useful check he recommended a circuit of vertical angles round a closed figure, and in season 1852–3 Logan made such circuits on the Rahun Series with considerable success Renny-Tailyour also reported the results of such a check-up through his stations in Kumaun [21];

The angles were generally taken at times of mimimum diurnal refraction and the stations from Banog to Ghoongti and Dhela were all visited in regular succession from November to the end of January when the temperature is nearly equable. Then, owing to snow having fallen on the mountains, and the expediency of taking the angles at the stations in the terai during the healthy season, the tower stations were all visited before the hill stations of Birond and Saunchalia [IV, pl. 4].

The results confirm the laws which previous experience had suggested ; viz., that when reciprocal vertical angles are taken at times of minimum diurnal refraction, and at the same season of the year as regards heat and moisture, the results are very trustworthy, and a high degree of accuracy may be expected from them, more especially if the angle at each station is the mean derived from repetitions on several successive days. ...

Three differences of heights are rejected. ... In the first, error is traced to...the observations at Bagwara having been taken from 28th February to 3rd March, and the reciprocal ones at Saonchalia on the 18th and 23rd of May. The observations at each station are accordant among themselves...but owing to the difference in the seasons...the elevation at Bagwara was too great relatively to the depression from Saonchalia. ... This would...tend to confirm the necessity...of observing strictly at times of minimum diurnal refraction, and of repeating the observations on several successive days.

By comparing the results now sent with the heights previously obtained, ... you will perceive the great improvement...in the quantities combined in the mean height. ... This must chiefly be attributed to an improved system of observing obtained from following the rules established by experience[2].

In his order on refraction of September 1852 [64–5], the Surveyor General made the following notes about vertical angles ;

The vast improvements recently introduced into modern instruments, more particularly as regards the sensibility of the levels attached to them, enable the Geodesist to attain a degree of accuracy and precision little, if at all, short of the most refined levelling operations, provided those precautions are not neglected. ...

When an observer happens to be detained several days at a station, he should be careful to repeat vertical observations daily, because the mean of several days successive observations has been found to give more satisfactory results. ...

The value of the results may be tested by levelling round the triangles [75]. ... Under favourable circumstances the discrepancy which may be expected...in closing a circuit of three sides should not be more than one foot...in 30, 40, or 50 miles, not much exceeding what would occur with the levelling instrument[3].

He issued definite orders for the careful reading and recording of the theodolite level, the determination of its scale value, and the correction of the vertical angles from these readings[4].

In a later note he discusses "the best mode of dispersing the error of origin and closing" of heights derived from "trigonometrical levelling" by means of vertical angles carried through a series of triangles[5].

REFRACTION

The bending or curvature of a ray of light or line of sight when passing from one transparent medium to another, or through layers of different densities, is a well-known optical phenomenon. Its special interest to surveyors was first realised

[1] DDn. 493 (306), 7–6–50. [2] DDn. 569 (4), 30–8–52. [3] DDn. 718 (243), DO., 13–9–52. [4] CL. 105, 10–9–45 & DO. 1–9–49. [5] TS. XV, NE. Longl. (30–3) ; SG.'s 12/57 of 27–1–57.

by Everest when in 1822 he found that a distant object, which during the day was entirely concealed below the horizon would rise to view as night approached, and offer a favourable target for the theodolite if illuminated when refraction was at its maximum [III, 235, 249 ; IV, 105–7].

He fully realised how greatly this strange phenomenon affected his vertical angles, and hence his insistence on the importance of reciprocal observation of every ray. The value of this latter precaution was seriously reduced when the reverse observation was not simultaneous with the first, and for this reason all the vertical angles of the Great Arc across the Jumna plain were observed by a team of observers working in concert under Waugh's direction [IV, 41, 93 ; *inf*].

To counter the vagaries of refraction arising from grazing rays, Waugh directed his surveyors working across flat country to restrict the sides of their triangles to an average of about eleven miles, and to gain adequate height above the ground by means of towers or other elevations [101, 104]. Amongst his many letters and circulars on the subject he writes to Nicolson in Assam ;

Every exertion should be made...to observe verticals at minimum refraction, for those taken later are worthless. About half-past three p.m., or as soon as objects begin to steady for horizontal angles, they rise at the rate of 1″ per minute, or even more rapidly. Thus a few minutes difference of time will cause greater errors than observing unsteady objects. As a rule it is better to observe verticals too early than too late, for even at noon the uncertainty of several intersections to an undefined dancing object would not much exceed 2″. ...

If your sides...do not exceed 11 miles, your stations always on high ground, the tower sufficiently high, and due care taken to avoid intermediate obstacles, ... there will be no difficulty in getting verticals at minimum. The period of minimum refraction lasts...probably from noon to the epoch of maximum temperature, which is generally...about 3 p.m. As soon as the thermometer begins to fall objects begin to rise, and it is the evil effects of this uncertain change in altitude which it is desirable to avoid. ... It is a good habit to observe reciprocal verticals at exactly similar times. ... Perfect equality of time is an essential element of success. ... It is the time from apparent noon which should be recorded...and not watch times[1].

Stimulated by observations to the snow peaks Waugh gave much thought to the subject of refraction, consulting his more experienced surveyors and the Chief Computer, and in 1852 he issued this important departmental order [63, 65].

An opinion appears to have prevailed...that geodetical heights derived from vertical angles are not trustworthy, but only a rough approximation to the truth. ... Refinements being... pronounced unattainable, a tendency is likely...to neglect those precautions on which accurate results depend. Limited as our knowledge even now is of the laws affecting terrestial refraction, still some facts are well established, and experience suggests many precautions. ...

Terrestial refraction...attains its daily minimum at the hottest period of the day, and its maximum at the coldest, the former being about 3 hours after apparent noon, and the latter just before sunrise. ... There is also a difference...at different seasons of the year. ...

In hilly countries...the seasonal variation...corresponds with the change of temperature, but in the plains...the stratum of air next the ground is sometimes colder than the air immediately above, producing...a very high refraction in calm clear nights after a hot day. On the other hand, in winter, the stratum of air next the ground is often hotter than the air above, producing a low rate of refraction at night. ...

In the mathematical treatment of the...problem...an assumption is made that the terrestial refractions at each end are equal. ... Although we know accurately the sum of the two refractions, we cannot assign the true value of either singly [65, 90]. ... Hence the judicious ...observer...will be careful to take those observations under circumstances that warrant the treatment of the refractions as equal. ...

Reciprocal verticals should be observed simultaneously if practicable but as the means are seldom available for simultaneous observations, which require two good observers with good instruments, the next best precaution is to observe them at identical times from apparent noon. ... When observations at one end of a ray have been made at one season, and a considerable interval has elapsed before the other end can be visited, it will not answer to combine reciprocal observations [62]. ...

In the case of a grazing ray, the object observed must be well free from contact with the ground. ... The observations should be simultaneous. ... When simultaneous observations are

[1] DDn. 573 (4), 21-7-52.

impracticable, the signal should be raised on high trestles ; the corresponding times should be perfectly identical; ... if...the result...turns out unsatisfactorily, an intermediate station of observation may be used [62][1].

Surveyors in the Punjab and in Kashmir were called on to make careful investigations, and on the Jogi-Tila series Walker had several of his grazing rays run over by spirit-level to determine the precise differences of level between the terminal towers. These confirmed the importance of restricting vertical angles to the hours of 1 to 3 p.m., more especially in the plains[2] [53].

In some areas surveyors were troubled by mirage and other eccentric phenomena of refraction [62, 68]. The Surveyor General writes to Clarkson working on the Coast Series through Hijli ;

Swamps and wet lands will...render objects agitated and somewhat obscure. ... Mirage... will give rise to double image and columnar appearance [IV, 106–7 ; V, 57]. ... Generally speaking the reflected or false image is the lower one and faintest, but it is advisable to avoid observing such objects. ... If the vertical angles are...much affected...it is best to have...some intermediate secondary stations...by...which...the relative heights of the two principle points can be deduced [62]. A comparison between the results...will be very interesting[3].

Strange and Nasmyth had such trouble when crossing the Runn of Cutch ;

The extraordinary disturbances continue uninterruptedly during the whole day. The vertical angles...were taken at time of minimum refraction, and even then most extraordinary appearances were seen. The heliotrope though pretty fairly defined was in...violent motion ; ... double false images of the sight-vane and of the signal men being frequently projected suddenly in the air in an inverted position. The observations *inter se* were accordant, but I feel sure the result is worthless.

The forms assumed by hills seen across the Runn are very curious. These phenomena no doubt are occasioned by the action of the direct and reflected heat of the sun upon an atmosphere irregularly charged with vapour [IV, 107 ; V, 68, 118][4].

The Surveyor General was particularly interested in the problem of vertical angles taken from one direction only, as in observing to the snow peaks[5]. In a letter to Logan written in 1845 [81–2] he recommends the deduction of a factor from several pairs of reciprocal observations made in the locality of the survey, on the assumption that refraction is equal at both ends of the ray [88].

Some observers adopt a mean refraction deduced from the whole series of triangulation or they employ a factor deduced from other geodetical operations of celebrity, ... but the factor obtained on the spot appears preferable, as better adapted to existing circumstances of locality and atmosphere.

Refractions observed in the climate of France or England are not likely to assimilate with others made in the torrid zone, nor is the refraction at a station little elevated above the sea likely to be the same as the refraction on a lofty mountain where the barometric pressure and temperature is so much smaller.

He described the procedure followed by Henry Colebrooke in working out the height of Dhaulāgiri [II, 87, 386 ; V, 81]. This was to apply a number of different coefficients in turn to all the observations and to accept that which gave the most accordant results[6]. He discussed this further in his Departmental Order of 1852 [64] ;

It is clear that all the values of the height of an object should be identical. If, however, the greater distance gives the greater height, then too little correction has been applied, and the ratios may be altered judiciously to produce consistent results.

At the northern extremity of the Great Arc the mean terrestial refraction was found to be nearly 1/15th [0·066] of the contained arc, ... but this ratio is applicable to dry weather and peculiar local circumstances. In the Darjiling operations [83, 90–1], on the other hand, the mean...was found to be 1/13·2 [0·075] of the contained arc, or 1/12·8 [0·078], computed by the true radius of curvature. These ratios are, however, applicable to a very moist climate, and the months of October and November[7].

In the mountain operations crossing the Himalaya [202–3], ... attaining an altitude exceeding 17,000 feet, the mean terrestial refraction was found to vary with the season. March, 0·06 [1/16–6]; April, May, June, 0·07 ; July, August, September, 0·08 ; October, 0·06[8].

[1] GBO. Comp. M-9-5 ; DDn. 455 (176–81), DO., 13–9–52. [2] *GTS.* II, appx. (XX, 77–93) DO., 13–9–53. [3] DDn. 598 (9), 18–4–50. [4] DDn. 615 (195), Strange to SG., 7–4–52. [5] note John Wood's doubts for his obsns. from Kābul R. [IV, 278]. [6] DDn. 499 (110–3), 26–8–45, quoting *As R.* XII, 1818 (266–72). [7] Hunter (1–5) finds more 0·064 suitable. [8] DDn. 718 (243), DO., 12–9–52.

Waugh was thinking on the right lines, but a great advance has been made since his day. Even during his own observations of 1837 on the Great Arc [65] "the subtended angles...were frequently found to vary between limits far exceeding those of the errors of observation, thus showing that the reciprocal vertical angles were not equally affected by refraction though observed simultaneously[1].

Repeated experiments made during the present century have been exhaustively analysed in Henry Shaw's *Professional Paper* No. 11, of 1911, and Dr. Hunter's No. 14 of 1913.

TRIGONOMETRICAL HEIGHTS

Neither Lambton nor Everest had gone deeply into the subject of heights above sea-level. Lambton first connected to the sea at Madras in 1802, but for his great central arc he preferred the connection made at Cape Comorin in 1809. From this he brought up his height by vertical angles from station to station to give a height of 2,026 feet at Damargida near Bidar, in latitude 18° 3'[2]. He hoped to get a check on this value at Bombay through Everest's branch triangulation [III, 234], but when Jacob eventually completed this connection which shewed that the Damargida height was about 75 feet too high, it was too late to make any change. The discrepancy of some 200 feet found by connection to the Hooghly at Calcutta had been distributed through Olliver's series between Calcutta and Sironj [IV, 93–4].

In 1848, after the measurement of the Sonakhoda base, Waugh had Everest's heights of the Calcutta base-line towers revised for use on the Calcutta Meridional and East Coast series [71]. The new values were then carried up through the North-East Longitudinal to Banog at the head of the Great Arc, giving it a height of 7,454 feet above sea-level [21, 70, 238], and then through the North-West longitudinal to the Chach base and Kashmir. This height of Banog was compared with that of Dehra Dūn by barometer [69, 137], and confirmed that the old Great Arc heights were too high.

Waugh realized that heights deduced by vertical angles would be influenced by the attraction of the Himālaya mountains [136];

> Originating at the sea and proceeding inland towards lofty mountains, it is obvious that the plumb-line must have an inland deflection that will tend to raise the apparent horizon on that side, and thus diminish the apparent altitudes. On the lower ranges of the Himalayas this deflection amounts to 30", and at a distance of 40 miles in the plains it may be estimated at 10". In this distance alone, therefore, there would be a diminution of 20 feet.

Running the heights from Jacob's connection at Bombay through the Bombay Longitudinal, the Great Arc, and the Calcutta Longitudinal to the south end of the Calcutta base-line, he found a discrepancy of only 4·6 feet, which made Lambton's height for Damargida about 78 feet in excess.

> Northern Hindostan can be connected with the sea only by...operations averaging 1,000 miles in length, and no verification can be applied by reference to the sea-level at the termination of these series. ... I had always felt great anxiety concerning the...heights. ... The differences of level of the Great Arc were brought up from the sea at Cape Comorin, and are unchecked along the whole course of...no less than 1,540 miles to the Himalaya mountains [75].
>
> The southern section as far as Beder was executed with instruments constructed before accurate levels were invented. At the same time the laws of terrestial refraction were not in those days well understood, nor were the precautions now deemed necessary in observing vertical angles recognized. ... From the Beder base the Bombay Longitudinal series...connects with the sea at Bombay...and shews the Great Arc in excess 78·4 feet.
>
> The datum of the Calcutta Meridional series is the sea-level deduced from the tides at Calcutta. ... The N.E. Longitudinal series proceeds...for 704 miles. ... The verification thus obtained gives the Great Arc in excess 74·8 feet. The operations are modern and were executed with instruments furnished with good levels, the observations having been taken by experienced observers with all due regard to the most rigorous precautions[3].

[1] *GTS. IV & Syn.* II (xi-A) [2] modern value, 1937 ft. [3] DDn. 580 (42), 13–11–52; cf. DDn. 616 (213), to Strange, 22–8–51.

Through the agency of the Bombay party Waugh now hoped to make a new connection to the sea by way of the Great Longitudinal series to a tide-gauge on the Gulf of Cambay [57, 72]. A suitable site could not be found, but a good connection was eventually established at Karāchi [74], and the first results were compared against Jacob's connection at Bombay, brought through the Bombay Longitudinal to Damargida, through the Great Arc to Sironj, and then by the Great Longitudinal, a distance of about 1,500 miles. There was a discrepancy of about +10½ feet, whilst that calculated from Calcutta through Sonakhoda, Dehra Dūn and Sironj came to about 19 feet. In discussing the best way to distribute the errors, Waugh pointed out that Jacob's work was the weakest ;

The sea-level at Bombay was determined...from 2 high-waters and 3 low-waters. The vertical observations along his series are meagre, many cross-rays being omitted, and no continuous connection preserved along each flank. In the few instances in which double deductions occur, they differ considerably, in one instance as much as 13 feet. On the other hand, in the section of the Great Arc, night verticals have been admitted [III, 245 ; V, 80][1].

In the southern section of the Great Arc, ... one of the values of height of Ikjhera differs 60 feet from the nearest of the other two. ... There is a discrepancy of 46 feet at Terban, and one of 65 feet at Shivni, with no third value checking the results [III, pl. 18]. ...

There are no such large discrepancies on the northern part of the Great Arc, but they are somewhat more numerous. One or two extreme differences amounting to 10 feet exist in the Great Longitudinal series [IV, 93–4][2].

The Surveyor General now called upon the Chief Computer to put in hand a general adjustment of heights and dispersal of errors for preparation of a general chart. These heights would be provisional pending the connection to Karāchi by spirit-levelling [75] ;

The error of the Calcutta Longitudinal Series...has been provisionally dispersed. ... It forms the lower connecting bar of the gridiron. By means of the several meridional series the heights of the North-East Longitudinal...can be compared with those of the Calcutta Longitudinal. The North-East Longitudinal is reckoned more trustworthy than the Calcutta Longitudinal because it is more modern, and was executed by better instruments, under a better system. The superior trustworthiness...is also demonstrable by the two circuits from sea to sea into which it enters, ... the error in one instance being only 6¾ feet in 2,127 miles, and in the other 16½ feet in 2,082 miles [75].

The inferior character of Mr. Joseph Olliver's operation is demonstrated by an accumulated error of 99¾ feet generated apparently in less than 700 miles[3] [III, 264 ; V, 66].

He found the errors generated in each of the meridional series, Budhon to Gora, varied from 33 to 85 feet, but claimed that his own work at the southern end of the Ranghir series had proved very well, but that further north "large differences immediately occured, partly owing to the large triangles adopted by my successor in the plains[4]". These deductions were later confirmed by spirit-levelling.

In a later note Walker points out that Olliver had not been "aware of the necessity for changing face, ... nor was the proper hour for taking vertical observations discovered till later[5]".

SPOT HEIGHTS

Under instructions from the N.W.P. Government Vanrenen's revenue survey party in north Rohilkhand was required to run lines of level to facilitate the drainage of swampy land [258–9], and in 1850 the newly-formed Government of the Punjab asked the Deputy Surveyor General to arrange for the contouring of the several *doābs* by his revenue survey parties, mainly for the use of the canal engineers. The Surveyor General thought this would burden the revenue surveyors and seriously interfere with their primary task. To be of any value, contours would have to be at vertical intervals not greater than ten feet and the expense would be prohibitive.

[1] DDn. 592 (96), 21–7–54. [2] DDn. 594 (161), 9–8–54. [3] instead of 201·3 ft. estimated by Everest [IV, 94 ; V, 66, 71]. [4] DDn. 665 (316½), SG. to Ch. Compr., 27–1–57. [5] OBO. Comp. M-9/8 ; 1–7–62.

An impression has been created that the Revenue Survey parties can carry out contouring at leisure and without extra cost. ... It will tend greatly to retard the progress [262–3]. ...

In England the contours are not taken up till the topographical details have been finished and plotted, and I would recommend that no departure should take place from this sound rule. ... To enable the two separate processes to be combined...numerous marks should be left, and perhaps the most convenient points of reference, in addition to all existing objects, would be the trijunction boundary marks of villages which, together with the trigonometrical stations, can easily be connected by the contours [52]. ...

Colonel Cautley [IV, 479]...thinks with me that 10 feet contours would answer the objects of the Canal Department in the upper *doabs*, wherein the ground slopes at 30 feet a mile or thereabouts for a few miles, and then gradually diminishes to about 3 or 4 feet a mile at a distance of 40 or 50 miles. The lower *doabs* slope at the rate of 1 foot a mile or less. ...

With the exception of the ground immediately at the foot of the hills, the whole country presents to the eye a perfectly level plain, but the general slope is clearly indicated by the elevations of the trigonometrical survey[1].

The proposal was abandoned but in 1852 the Government of India asked whether it would be possible to show the height above the sea of all *obligatory points* throughout India, having reference to the construction of works, draining, irrigation, etc., such as the highest points or necks of valleys, the low passes of mountain ranges. ... The heights of numerous points of inundation level...upon the rivers...to be taken at intervals of two or three miles[2].

The Surveyor General answered at length pointing out the vast amount of labour and expense that would be involved. He had already issued instructions that such heights should be shewn by the few topographical parties that were engaged in hilly areas [213–4]. The fixing of heights, however, in the wide areas of flat or undulating country covered by revenue surveys would entail special levelling operations and heavy expenditure. The heights fixed by triangulators were "of a fair degree of precision", but only available in the higher ground.

For irrigation projects he pointed out that "the levels require to be determined with great precision and in considerable...detail", and thought that it would be more economical to confine the provision of heights "to the particular localities or lines along which such works are required". They would be of no great value to the general maps of the Surveyor General's department. It would cost about Rs. 3 per square mile to provide lines of levelling to contour the plains[3].

No general map can ever supersede the necessity for special plans on an enlarged scale for special purposes, and such operations are always carried out by the engineering department in connection with such projects.

The demand was not pressed. It was not thought "expedient to burden the Surveyor General's Department with the proposed levelling operations or to alter the scale of the maps. ... On future maps the heights of marked points may be marked"[4]. Two years later, however, the Punjab canal department asked for a regular series of levelled bench-marks[5];

It would be of the greatest use if the accurate height above the sea-level of fixed points at certain intervals all over the country could be given by the Grand Trigonometrical Survey department. We might then reduce all our work to one unvarying datum, and a new line of levels might be run at any time with the certainty of its being generally useful and perfectly accurate. ... If these were laid down even at distances of one hundred miles apart, the saving of circle levelling would be immense. ... The permanent bench-marks which would be established at intervals can scarcely be too solid or well secured. Their height above the sea-level should be clearly written on each, so that there would be no possibility of mistake[6].

Though the systematic erection of "Standard Bench-marks" by the Great Trigonometrical Survey of India was not instituted until 1903[7], this application and other early demands gave stimulus to the start of spirit-levelling, and to the fuller display of spot heights [320]. The Surveyor General comments in 1859 on Atlas Sheet 47, covering part of the Punjab hills;

[1] DDn. 561 (134), SG. to DSG., 12–9–50. cf. contouring for *Reclangulation, PP.* 21, 1927 & *Riverain Svys.* RECORDS SI. XXIV, 1934. [2] DDn. 552 (1), from Maj. Kennedy, 14–9–52. [3] DDn. 561 (331), SG. to DSG., 28–9–53. [4] DDn. 552 (2), Govt. of India to DSG., 18–11–53. [5] Plan of Bari *doāb* canals, 5 sheets; 25 m. to 12″; MRIO. 160 (8–12); *IO Cat.* (139); Joseph Dyas, Ben. Engrs., Lahore, Oct. 1850. [6] DDn. 644 (104), Lt. Dyas to CE. Lahore, 8–2–55. [7] *GR. 1903–4* (53).

I regret to observe that nearly the whole of the heights have been left out. The numerical values of heights are now considered of the greatest importance in maps as data for engineering designs and geological researches, as well as general purposes of interest. The combination of the results of trigonometrical levelling...with special direct levelling operations is calculated to afford a uniform system of levelling for the whole of India, and the interest and information thus afforded by the sheets of the Atlas of India will greatly enhance their value[1].

In 1850 the Surveyor General had arranged a series of barometric observations between Dehra Dūn and Banog as a check against the heights deduced by long lines of trigonometrical observations [66, 137]. He had already made such tests during his operations in Sikkim during 1847, and had directed the Deputy Surveyor General to obtain a precise value for the height of the barometer at the Surveyor General's Calcutta office by levelling up from the tide-gauge at Kidderpore [70];

I find a necessary element...wanting, viz., the height of the cistern of the Calcutta standard barometer above sea-level. ... My own barometrical observations comparative with those taken in Calcutta consist of heights observed in the Sikkim mountains as a check on the trigonometrical operations, and for...investigating the effects of terrestial refraction in the mountains. Also barometrical observations taken at the Sonakhoda base-line for...verifying the trigonometrical operations between it and Calcutta[2].

On the Kashmir survey Montgomerie made considerable use of boiling-point measurements, and reported at the end of his first season that

barometrical observations were made at all the principal stations. Thermometers were put into boiling water at the same time. The thermometers were also boiled on the summit of all the remarkable passes. ... The three barometers...reached Srinagar in safety, and two of them reached Dehra, and on comparison with the standard barometer were found to agree well with the comparisons made before they left Dehra. The third...was not in adjustment, the mercury having escaped [III, 221–2 ; V, 228][3].

In a circular order of 1861 the Surveyor General gives detailed instructions for the comparison of thermometers with the standard. Heights were to be taken by these thermometers on all trigonometrical stations where heights had been determined by trigonometrical means, and the thermometers were to be boiled at recognizable points close by, making record of the exact position, besides time and temperature of the outside air and of the boiling water.

The boiling thermometer should be put into the cold water so that it may be heated up gradually, and in putting it away the thermometer should be exposed as little as possible to the colder air[4].

The Aneroid had been invented about 1843 [III, 222], and was not yet in common use. A paper "on the adaptation of the aneroid for the purpose of surveying in India" was read on 24th of February 1851 before the Royal Geographical Society in London by Dr. George Buist of Bombay [72, 139][5].

TIDAL OBSERVATIONS[6] ; BAY OF BENGAL

Surveyors in India had no professional interest in the measurement of the vertical rise and fall of tides along the coast except to find the level of the sea from which to calculate their land heights. Lambton followed the practice of his time in calculating his heights from low-water, and it was not until Professor Whewell published a paper on Tides in 1837[7] that it was realised that "low-water not only is...indefinite, varying considerably with the...moon and sun, but it is...not even approximately a level surface at all". The mean between high and low tide determined from observations of at least half a month had now been proved to agree closely from one place to another[8].

Tidal observations had been carried out unofficially for other purposes at Kidderpore on the Hooghly from 1806 [1: 347], at Madras during 1821[9], and by Henry

[1] DDn. 675 (3), SG. to DSG., 12–1–59. [2] DDn. 473 (23–6), SG. to DSG.; 19–4–48. [3] DDn. 692 (110), 20–3–56. [4] DDn. 53 (79), memo., 166/61. [5] Dr. Geo. Buist (1805–60), LLD.; Ed. *Bombay Times* 1848, 57; Sec. Bo. Geogl. Soc., *JRGS.* XIX, 1849 (xc); XXI, 1851 (45–47). [6] Markham (311–7). [7] *Phil Trans.*, 1837, *Historical account of Tidal Research*; *GTS.*, XII (3–4). [8] DDn. 506 (133) from SG. 10–3–45, *GTS.*, II (150). [9] *JASB.* IV, June 1835 (325–6).

Siddons at Chittagong in 1837. A self-registering tide-gauge had been invented in England in 1830, and in 1833 Professor Whewell had asked that observations should be made along the coasts of India[1] [IV, 119].

The Directors saw no reason to incur any considerable government expense, but suggested in 1834 that "wherever scientific men may happen to be stationed within the tide-way, they would no doubt readily undertake the duty", with but "small expense" to Government [IV, 119]. From 1842 a self-registering tide-gauge was established at Colaba Observatory, Bombay [III, 191–2], and maintained under the direction of Dr. Buist and others. Spasmodic observations were carried out along the coast by officers of the Indian navy, but seldom continued for more than a month.

Everest made his first connections to sea-level in March 1835 when he had a line of levels run from the south tower of the Calcutta base-line to the Hooghly river at Cossipore Ghāt close by. Another connection was made in May 1839 between the north tower and Salkhia Ghāt about a mile above Fort William [IV, 49]. In neither case was the state of the tide recorded. In calling for connection of the Survey-office standard barometer to the Kidderpore tide-gauge [69] Waugh pointed out that

the Hooghly river may be considered to be a channel communicating freely with the sea. ... The mean sea-level used in former times was low-water of spring tides, and more recently a point was assumed at one third the rise of the tide. Both of these suppositions are erroneous, and the true mean level now used by scientific men is the mean of high and low water. ...

The height of the tides is regularly registered at the Kidderpore dockyard. ... Ample data must be forthcoming for determining the true level of mean water. ... They will also show whether the mean level is higher during the southerly monsoon. ...

If the Kidderpore...observations are available, then all that is necessary will be to level from the Surveyor General's office to the tide gauge. ... If...not available, then it will suffice to level to the nearest point of the river, and measure the rise and fall of the tide during a semi-lunation. ... It would be advisable to leave fixed marks of reference at each extremity[2].

Thuillier made the connection to his office, and co-ordinated his levelling with that carried out by Simms for the survey of Calcutta [71, 183];

The zero or datum line on which all the levels have been calculated is the bottom or sill of the stone of Kyd's Dockyard, a point which will always be readily identified. ... From a bench-mark in the main Chowringhee Road, the top of the little post of stone against which the main gates of the Sudder Board of Revenue compound shut [IV, 332–3] was observed to be 23 feet 8 inches above the zero of the tide-gauge, ... and from this a mark...has been left on the sill of the verandah of the Revenue Board Office immediately opposite the little door leading into the observatory compound, and which reads feet 24·14 above the said zero, from which point the surface of the mercury of the standard barometer...was observed to be feet 26·59 above the datum line.

A transcript of the Register of Tides as kept at Kyd's Dockyard has been obtained. ... It appears that the mean of high and low water above the zero of the gauge during this entire period is feet 10·84. ... The difference...being so considerable during different months, ... it does not appear advisable to adopt the result of a semi-lunation. ...

I have found two papers bearing on this subject. One by Lieut. Schalch on the formation of a canal [III, 14], ... and the other on the level of Calcutta above the sea by Captain Cheape[3]. In the memoir by Captain Cheape...some distrust is noted regarding the tide observations. ... The height of Chandpaul Ghat is assumed at feet 16·47 above the mean level of the sea from observations of the surface of the Salt Water Lake, and this was adopted in determining the height of the old observatory in Park Street [III, 189]. The exact spot called Chandpaul Ghat cannot now be fixed[4].

The Surveyor General noted that the Kidderpore register clearly shewed

that the locality of Calcutta is unfavourable for determining with great precision the level of the sea, ... from the length of the channel which tides have to traverse, and the rise of the river in the rains. ... The monthly mean tide of the sea itself should be an uniform level, affected only to a slight degree by the pressure of the wind[5].

[1] and again Whewell to CD., 22–12–37 *JASB.* VII, 1838 (577). [2] DDn. 483 (236), SG. to DSG., 19–4–48. [3] ASG. Calcutta, 1823, 1825 [III, 433]. [4] DDn. 459 (188–91), DSG. to SG., 5–6–48 ; *GR Trig., 1862–3* (9.n). [5] DDn. 473 (36–40), 16–8–48.

It was during 1848 also, after the measurement of the Sonakhoda base-line, that Waugh deputed Thorold Hill to get a new value for the height of the Calcutta base-line to serve the East Coast and Calcutta Meridional series [21, 66];

I do not consider the old data perfectly satisfactory. ... The height of low-water at Cossipore Ghat and of high-water at Sookchar Ghat were...derived from single determinations, to which the mean monthly rise and fall...is clearly inapplicable [69]. Even this monthly mean range was not ascertained on the spot, but at Kyd's dockyard, several miles lower down the river. ... But...I do not think the present determination can be far wrong. The two ends of the base were separately determined, one by low, and the other by high, water, and the difference...agrees precisely with the trigonometrical determination. ...

As the Kidderpore Dockyard datum and the level of the cistern of the standard barometer of the S.G.'s office are well-determined points, it would be advisable to connect one or both with your work. ... A line of levels could be carried from...Kidderpore Dock to the south end of the base with a good dumpy[1].

Hill's work gave revised heights of 84·33 and 87·33 feet above the sea for the south and north towers respectively [IV, 94], which

agree better with the altitudes brought down from Sironj, the discrepancy in which will be reduced from 201·3 feet to 199·1 feet. Moreover the new deduction will make the trigonometrical altitude of the Sonakhoda base agree better with barometrical computations, although... no great weight can be attached to such slight differences amongst discordant elements[2].

Between 1851 and 1854 the subject was exhaustively discussed between Waugh, Thuillier, and Bedford the river surveyor[3]. The latter had run a line of levels from the tide-gauge at Kedgeree on the open sea to the Kidderpore gauge, which he considered within 9 inches of the truth. This was extended to the base-line by a series of levels taken by Captain Thuillier, ... Radhanath Sickdar, ... and Said Mohsin... in October 1853, starting from Mr. Simms' bench-mark at Chitpur bridge, and verified by another series of levels from Mr. Simms' value...of Barrackpore bridge.

The new correction deduced was a matter of about 12 inches [80][4].

As Hill advanced the Coast Series southwards the Surveyor General directed him to make connection with the Kedgeree tide-gauge, and an attempt was made in 1849 to find height above sea-level taking the angle of depression at Gangra to the visible horizon [25]. The tide-gauges along the river and at Kedgeree were under the charge of Bedford, who gave every assistance in making the connections. Similar orders were given to Peyton; "With the sea so close, false altitudes would be intolerable, and would compromise the reputation of the series"[5].

During season 1853–4 Peyton made a connection at Balasore, taking observations for a full month from 8th December to 10th January, with readings at 5 or 10 minute intervals before and after each high and low tide [27, 73].

The tide-gauge was fixed near the entrance of the Baroda Creek which communicates with the Boorabalang River about ½ of a mile from...the sea. The position of the tide-gauge...was further protected by a palisade and matting of bamboo, which completely secured it against wind and waves, ... so that the observations may be said to have been made in a mill-pond, the water line...being read off to the 100th of an inch. The gauge was a...rod of sal wood carefully divided into feet and tenths, and inserted into a thick post firmly driven into the bed of the creek to the depth of about 8 feet under ground. ... A pillar was erected at the distance of 410 feet...rigorously connected with the triangles of the Coast Series[6].

The Surveyor General later directed Strange to take every opportunity of making connection to existing tide gauges along the coast, or to gauges of his own siting and construction;

I take entirely a practical geodesist's view of the case, our object being to find a correct value for the sea-level, not to make researches into the theory of Tides, nor to gauge the permanence of level between sea and land. ... What I expect is a result true to less than 2 inches. ... My belief is that a semi-lunation at the periods of 6 months apart is sufficient to determine the sea-level. ... I believe one lunation at those two periods will confirm...the result, so that it is a matter of unnecessary refinement to take more[7].

[1] DDn. 483 (50), SG. to Hill, 26–8–48. [2] DDn. 561 (75), SG. to Ch. Compr., 4–9–49. [3] employed by Marine Bd. [4] DDn. 562 (124) Bedford to DSG., 8–8–51; 557 (149), SG. to DSG., 9–9–51; 561 (347), SG. to DSG., 9–12–53; 571 (36–9), Ch. Compr. to SG., 30–1–54. [5] DDn. 592 (227), SG. to Peyton, 3–8–52. [6] DDn. 672 (31), May, 1854. [7] DDn. 600 (154), SG. to Strange, 1–12–55.

At the end of 1860 another gauge was constructed for erection at Vizagapatam, the pattern designed by Strange having proved a failure. Observations were carried out between 16th November and 9th December 1860[1].

TIDAL OBSERVATIONS: WEST COAST

Jacob connected the Bombay Longitudinal series to sea-level near Bombay by observation to a pole set up on the shore from a station about 60 feet above the sea. He took angles of depression to two high and to three low waters. The heights so deduced were carried through the longitudinal series to Bidar, and shewed Lambton's height for Damargida to be about 78 feet in excess [66].

On the South Konkan series Rivers took similar observations from at least two stations. Those at Meria taken between 6th and 9th November 1845 gave the height of that station to be 464·4 feet above the sea;

The difference of level at high and low water at Meria Station was obtained by placing a pole of 8 feet high on a rock which was barely covered at low-water in a sheltered part of a small bay, where the water was quite smooth, and marking on the pole the height the water rose, which in 4 tides agreed to within 3 inches.

The distance of the pole was taken by subtense measurement, and the Surveyor General notes that Rivers' deduced height was

36 times greater than the base it is deduced from, and the subtended angle not more than about 16 minutes. The same principle was employed by Captain Jacob, but the height deduced was not more than 7 times the pole. ... It would have been preferable to have established... a supplemental point on the shore, ... taking care that its height...should not exceed 50 feet[2].

Rivers' observations extended more than a week. From the levels of high and low tide on three successive days he determined a mean level of 3·2 feet below the highest tide. Waugh pressed for more frequent connections;

The intent and object of taking vertical angles...is to determine...the true elevation above sea level, and surely... height can be more correctly ascertained by direct reference to the coast which is only 23 miles distant, than by deriving it through a long series of intermediate unverified stations from Bombay, which is not less than 274 miles distant[3].

In his first instructions to Renny for the Great Longitudinal series the Surveyor General suggested an early connection to the sea [37, 57];

As the heights of the stations of the Great Arc which will be your...datum points have been determined by a very long series of triangulation, in the early part of which inferior instruments...were used, and no part being verified for height, we may naturally apprehend accumulation of error. ... Consider whether after reaching Aboo it would not be advisable to send off a branch series to the Gulf of Cutch for the special purpose of verifying the heights. ... Perhaps such a series might advantageously be entrusted to the Bombay party [57][4].

This connection was the primary purpose of the Abu meridional series entrusted to Rivers in 1850, who approached the marine authorities in Bombay the following year for the loan of a tide-gauge, and levelling instruments. Neither instruments nor any trained leveller being available, a series of minor triangulation was laid out down the Sābarmati River, near the mouth of which it was hoped to find a suitable site for a tidal station [57, 159]. The offer of a self-registering tide-gauge was made by Dr. Buist [69 n.5] who wrote to the Marine Department in 1851;

The occasion of setting a tide-gauge to work for the...Trigonometrical Survey seems an eminently auspicious one for revivifying the scheme of tidal observations so cordially taken up by Government in 1845–6, to the promotion of which the Court of Directors pledged themselves to the British Association in 1847–8, and of which the only portion that has hitherto been carried out successfully is that at Aden.

A tide-gauge, the property of Government, was sent to Karachi in 1849; the fittings-up for it were afterwards forwarded in 1851. A second tide-gauge...was about the same time forwarded to Porbunder. No returns from the former of these have been received. The latter remains in store, the gentleman who undertook to take charge of it having left the station.

[1] *GTS.* vi & *Syn.* xiii (xxxv-vii—C). [2] DDn. 325 (441-9), 4–7–46; 518 (302), 3-11-46. [3] *GTS.* xiii & *Syn.* xxiii (iv-vii—C). [4] DDn. 493 (66) & 616 (8), 16–9–48.

With the Trigonometrical Survey on foot in Goozerat—a survey of the Gulf of Cutch in progress under Lieutenant Taylor [I.N.]—a survey of the Gulf of Cambay commenced under Lieutenant Rennie—nothing could be more desirable than the determination simultaneously with these operations of the tidal phenomena all along the shores adjoining. Other two tide-gauges, the property of Government, are at present in charge of the Society unemployed[1].

In January 1854 Nasmyth spent several exhausting days searching for a suitable site for the tide-gauge that had now been made available [57]. Embarking at Ghoga on the western shore of the Gulf of Cambay, and leaving the establishment to reach Khoon Bunder in a large boat, I hurried onward in a smaller one to the mouth of the Sabermuttee and commenced at once a reconnaissance. ...

The establishment were unfortunate in making the bunder. ... The high spring tides had flooded the country for miles around, and...a week had elapsed before horses, tents, or baggage reached their destination. Meanwhile, partly bestriding a couple of poles borne on men's heads, and partly on foot, I had wandered over the whole tract of mud through which the Sabarmutti finds its way to the sea.

All circumstances considered, Tarakpur was the most favourable point. I had found the ground there was hard, and there the structure would rest on a firm foundation...retired from the violent rush of the water, and yet the water would have perfectly free access to the gauge. ...

On one occasion I was well-nigh overtaken by the bore [74]. I was...crossing the river near its mouth, and while yet embarrassed by the velocity of the current, the first faint warnings of the approaching bore broke on the quick ears of my coolie companions, and anxious were the looks they directed towards it. A few strides and we should be out of the river, but ...beyond the water lay a tract of mud which we had yet to pass. We had scarcely gained the bank when the bore coursed past us up the stream, and then the nearest shelter was a miserable hamlet, to gain which we had to traverse some 10 or 12 weary miles of mud. ...

Mr. McGill on other occasions was in as awkward a dilemma. At the end of a laborious day the ground was his couch, and a tree his canopy, and though he resumed his work with the morning sun, the day was well advanced before his baggage had accomplished the detour necessary to pass the river.

He later decided that Tarakpur was not entirely suitable ; finding that the water at Tarakpur during neap tide was sufficiently sweet for cattle to drink, and as the observations could not in that case be considered free from the influence of the river, I determined on choosing some point nearer the sea, and continuing the triangles to connect it.

The point chosen is marked on the sketch, about 660 yards south-west of Sikotar Matha station. The mud...is hard. ... It is near to the point of meeting of the present and former channels, and therefore not likely ever to be left dry[2].

The Naval draughtsman at Colaba did not like the site, and the Surveyor General thought he was right [57] ;

The inland surveyor looks to the tide observations solely as the means of determining the mean sea-level...with regard to—... 1st., convenience of access and the shortest symmetrical connection with his triangulation—2nd., calm water, free from undulation in order that the heights of high and low water may be ascertained with the greatest nicety—3rd., the stability of the zero of his gauge or point of reference.

The timing of the tides is of no special interest to the surveyor, except as an index to the observations for height. ... On the other hand to the Naval man the times are all important. ...

I consider, therefore, the objections urged by Lieutenant Fergusson to be quite conclusive against the locality selected by you as a station for naval observations, or for general purposes of science. ... If a tide-gauge is to be erected by the naval authorities, ... the site should be suitable for general purposes, ... and not merely...to suit our convenience. ...

If the surveyor drove a tent-peg to mark high and low water, and connected the same with his station immediately, ... the results for 2 or 3 days would not err more than 5 or 6 inches. ... The result of a whole semi-lunation may be taken as true to less than 2 inches. However unscientific such a process, ... the result would be...knowedge of a most valuable kind. ...

The result of Mr. Peyton's tidal observations shows that an error of 5·71 feet was generated in trigonometrical levelling over 80 miles of flat and very unfavourable country [71]. This is a gross error, nearly 5 times greater than the greatest uncertainty that could be introduced by deriving the sea-level from 2 successive tides, and probably 11 times greater than the uncertainty [of]...a few days observations with very simple means. ...

[1] DDn. 519 (112), 9-6-51 ; (119), 29-12-51 ; Cmdr. A. Dundas Taylor ; Markham (25, 45-8, 440, 478) ; appd. Supt. Mar. Svy. Dept. 1874, after suspension of Svys. from 1861; *IO Cat.* (594-5). [2] DDn. 720 (23), Report 1853-4 ; 613 (125), Nasmyth to SG., 4-2-54.

No gross error is likely to be introduced by restricting the observations...to short periods at favourable times. ... Four or five such points along the coast of...Kathiawar to Mallia in the Gulf of Cutch would be very...valuable for correcting your heights. ... At one point, however, elaborate observations would be required as a special test. ...

The original intention...to obtain a speedy reference to the sea by the shortest line...has not...been realised. Sea-level has not been determined at Cambay. ... On the other hand, the triangulation has been extended all over the peninsula, and the Great Longitudinal series has been carried up to the sea at Karachi, and sea-level there obtained [42, *inf*]. ...

It will be best to abandon the intention of taking the sea-level at Cambay. ... Near Diu a favourable spot may be obtained. Tidal observations appear to have been formerly taken at Porbunder. ... You may find a favourable position for independent tidal observations... near your hill station of Koyka [near Miāni][1].

Connections were therefore made to the sea at Miāni and Diu during 1855 by Da Costa, who made one more effort in the Gulf of Cambay without success [57–8].

His first tidal station was selected in Miani Harbour, 35 miles south-east of Dwarka. His tide-gauge, ... self-registering, had been previously prepared...under the direction of Lieut. Nasmyth. ... The observations...extended from February 8th to 23rd. ... The zero of the gauge was referred to a stone masonry pillar which was connected both trigonometrically and by levelling with the adjoining station. ...

Similar observations were taken at Diu, in the creek which separates the island from the mainland. ... As the Portuguese authorities refused to allow a pillar to be built, the mark... was engraved upon the stone pavement of a martello tower that guarded the ferry, and was connected with...the Kattywar meridional series. The observations at Diu extended from the 3rd to the 17th March. ...

Mr. Da Costa next moved the apparatus to Bhavnagar [nr. Gulf of Cambay], but his scaffolding had hardly been set up when it was knocked over by the waves. Despairing after repeated failures of ever being able to secure a firm foundation for the piles at this place, ... Mr. Da Costa embarked in April for Sikotar Mata at the head of the Gulf. This station had been connected...by the Sabarmati minor series ; ... its site had been fixed upon by Nasmyth himself. ... Observations had hardly begun when the bore came up the Sabarmati and swept away the scaffolding and gauge, the observer himself having a narrow escape [57, 73][2].

Meanwhile Strange had, in 1853, brought his main triangles of the Great Longitudinal to Karāchi, where he took approximate observations for sea-level on three successive days in June, and connected with Manora lighthouse where sea-level had been determined by the naval authorities. Tennant then put in hand more extensive observations. He re-erected old gauge between the Ballard Pier and "what is known as Deep-Water-Point". Special piles were driven to support it, whilst the clock was housed in a shed on dry land, and connected to the gauge by wire.

The Surveyor General agreed to observations running several months. "In the case of the Great Indus series you will have no subsequent means of verifying heights. The series is a very important one, and should have independent...datum beyond cavil or dispute"[3].

Tennant had the tide-gauge and its apparatus working by November 1854, and his observations were continuous from 18th May to 17th October 1855. Having connected up to the principal triangles, he submitted in January 1856 a full report on the modifications he had made to the gauge, particulars of its erection, and the method of recording and computing the results[4]. He was the first survey officer to show any particular knowledge of the subject of Tides.

Markham records that regular tidal observations were maintained at Karāchi from 1857 by William Parkes, consulting engineer of the Harbour[5] [194].

SPIRIT LEVELLING

Spirit levelling had long been in general practice amongst all engineers for ascertaining the rise and fall of ground for drainage, irrigation, building, and other

[1] DDn. 718 (335, 368); SG. to Nasmyth, 23-6 & 13-9-54. [2] *GTS.* XIV & *Syn.*, XXX (XIII—K), XXXIII (XIII—L). [3] DDn. 621 (191), 16-5-54 ; 709 (86), 4-7-54. [4] DDn. 32 (1), 88, 17-1-56, Tennant to SG. *GTS.* XVI (119–21). [5] Markham (315–6).

projects [I : 52, 106–7, 192 ; II, 17, 67, 202–3 ; III, 14, 526 ; IV, 94, 417]. For the trigonometrical surveyor it was moreover essential in the measurement of base-lines and in connecting bench-marks at sea-level, where high precision was called for [III, 130, 526 ; IV, 45–6, 94].

The Surveyor General had suggested such levelling between adjacent trigonometrical stations when there was reason to suspect the accuracy of reciprocal vertical angles [IV, 107 ; V, 62–3], and it was on work of such nature that James Walker gained his first experience. During field season 1855–6 he was employed on the Jogi-Tila series in the Punjab [53, 65], carrying triangles across

perfectly level country where the stations of observation were towers raised to a height which was little more than sufficient to surmount the curvature of the ground, ... and where the rays...grazed the surface of the ground very closely. ... It seemed to be well-nigh impossible to obtain satisfactory determination of the true relative heights of the stations.

With the approval of the Surveyor General he employed one of his assistants in running lines of levels...between several of the principal stations, and he thus determined their relative heights with considerable precision. Meanwhile, ... I measured the apparent zenith distance of the signals at various hours of the day, and occasionally also during the night, in order that by comparing with...Mr. Carty's levelling operations, I might...ascertain the exact amount of refraction in each observation [65]. ...

Mr. Carty ran his levels...over the direct lines between the stations through the rays which had been opened. ... A few of the lines cross the river Chenab, and from these he was obliged to diverge to the most favourable points for levelling across the river[1].

Two spirit-levels and six sets of levelling staves had been borrowed from the canal department [272]. The levels were first tested and tables taken out for the "run" of the bubble for dislevelment correction. The staves were of *sal* and errors of graduation were as much as half-an-inch in ten feet, tests being made from a replica taken from the standard 10-foot bar[2] [158–60]. Walker's report on his successful results led the Surveyor General to follow up the subject, and he wrote to Walker after his move to the Indus series ;

Many years ago I contemplated the necessity for extraordinary levelling operations from the sea over the plains, in order to establish a safe datum for trigonometrical levelling in the mountains of upper India [48].

No country...is so unfavourably situated as upper India for trigonometrical levelling. Situated many hundreds of miles from the sea, ... there is no means of verification at the termini of the series by again referring to the level of the sea. ... The only means of verification...is by a circuit from...the Bay of Bengal up to the sub-Himalayas, along their course, and down to the sea at Bombay and Karachi [66].

From sea-level on the Hooghly heights had been carried by a long round-about route to the sea at Karāchi—northwards through the Calcutta Meridional Series—westward by the North-East Longitudinal to Banog—south by the Great Arc to Sironj—west by the Great Longitudinal to Karāchi—a distance of 2,082 miles, with an apparent error of 16½ feet [66–7]. The Surveyor General claimed that this result justified the conclusion that

if the plain part were regularly levelled in the way most suitable for flat ground, and combined with the trigonometrical hill levelling, we should have an excellent system...of connected vertical surveying for all India—... In level ground trigonometrical levelling cannot compete with ordinary spirit-levelling, and vice versa—in hills and mountains ordinary levelling is out of the question, while trigonometrical results are excellent. ...

The sea-level datum at Karachi has been determined in a most scientific...manner by Lieutenant Tennant with the aid of a self-registering apparatus whereby the mean sea-level was derived, not from successive high and low waters alone, but from the entire line of double curvature described by the tides, whereby the mean axis of the curve became the true mean level of the sea. The tidal observations being thus uninterruptedly continued day and night over several semi-lunar periods...inequalities have been compensated [74]. ...

As the series of levels...to be brought up from Karachi to the Punjab is most important, and all our...heights in upper India must remain provisional until the levelling operations are completed, ... it is desirable that the undertaking should be no longer deferred. ...

[1] *GTS.* II (XIX-XX) ; appx. 3 (77–81) ; IV (XXI—G) ; XIX, appx. 5 (451), Walker to Carty, DDn. 722 (291), 26–1–56. [2] *GTS.* IV (X, XXI—G).

Ordinary spirit-levelling has not hitherto been used in the Great Trigonometrical Survey to any great extent. Your operations of last season are the first in which the two systems... have been combined. Your report...of 15th July 1856 is a most valuable scientific exposition of...practical refinement. ...

It will...be necessary to draw up...instructions for the levelling parties—to organize those parties—and to estimate...and prepare all the necessary apparatus. It is proposed to level by circuits so...as to unite at central stations of polygons, giving the levelled heights at each end of the sides. ... The scheme will give a verification at every 44 miles on an average.

Each line of levels should be done by two levellers working together, although independently, each with his own instrument and measuring apparatus. ...

You already possess two standard levels. ... Any attempt to introduce a new design of instrument would involve us in all the delays incidental to the construction of new scientific apparatus, and the risk of untried designs. ...

The provision of the levelling staves is also left to yourself. They may be made up either by yourself...or you can indent on my workshop at Calcutta. ... It is very desirable to adhere to ordinary wooden levelling staves...provided they are well seasoned and graduated [161]. ...

You will require four native levellers in subordination to your European assistants[1].

It was not possible to start these new operations during field season 1857–8. Walker himself had been away on military service, and on the sick list. The new apparatus had taken many months to make up at Calcutta, and it had not been possible to collect and train the new Indian staff[2]. Waugh chafed at the delay ;

The result of ordinary levelling, if quickly obtained, would be highly appreciated, and...of immense benefit to...our own Department and elsewhere. ... Every map now publishing depends upon the old trigonometrical datum brought up from a great distance over unfavourable ground [66–7]. The new datum which the trigonometrical levelling and the Great Indus series will bring up will serve to check this result. ...

If the levelling operations were greatly elaborated or postponed...their results will very likely become a mere office record known to the Department alone. ... If a single line of levels is brought up from tower to tower as bench-marks, it will check the trigonometrical levelling, and any gross errors in either will be prevented[3].

Walker was reluctant to hurry. He envisaged this levelling as a work "of the utmost refinement attainable...to be worthy of the reputation of the Great Trigonometrical Survey for accuracy and precision". He thought, however, that

if the levels are only required contemporaneously with the triangulation, they may be conducted with greater refinement than usual, ... and yet be completed as soon as the triangulation. There is still upwards of 300 miles of approximate series to be done, and nearly 400 miles of triangulation, which cannot be accomplished before the end of season 1860–61.

In two field-seasons a refined series of levels may well be carried from Kurrachee to Dera Ismail Khan, or indeed to the Chuch base-line, if we are content with a single line. ... The only essential difference between the proposed and the common systems of levelling consists in recording the readings of the ends of the bubble, and applying the necessary corrections[4].

The Surveyor General accepted postponement to season 1858–59, but considered that work should commence with the section Lārkhāna to Dera Ismail Khān ;

As regards the North-West Himalaya series, the Kashmir operations, and the new map of the Punjab, a speedy result would be invaluable.

The levelling should either form circuits of single levels, or a single line should be twice levelled by two instruments and observers. I would express preference for the latter. ... It should proceed from tower to tower as bench-marks, such additional bench-marks being fixed as...desirable for the use of other departments and the public. ...

The plain levels should include at least two towers at each extremity of the series in the plains, so that the connection with the trigonometrical levelling may be double.

Colonel Walter Scott [192]...is desirous of obtaining our results for...combining with those of the Public Works Department which he is willing to place at our disposal [79][5].

Three Indian surveyors were recruited on trial ;

One, ... by name Ram Chand, was in the service of Mr. Schlagintweit, and accompanied him on an expedition into the snowy ranges to the north of Kashmir. He parted from his master when the latter attempted to penetrate into Yarkand, having first arranged that Ram Chand was to go to Lahore to take meteorological observations and await his return [144–7].

[1]DDn. 709 (307) ; 711 (2) SG. to Walker, 15–1–57 paras. 51–65. [2]DDn. 710 (188), Walker to SG., 12–12–57. [3]DDn. 711 (39), SG. to Walker, 14–12–57. [4]DDn. 710 (189), Walker to SG., 21–12–57. [5]DDn. 711 (48), SG. to Walker, 3–3–58.

He received Rs. 60 a month and travelling expenses from Mr. Schlagintweit, but I have arranged to pay him half that salary until be can be permanently released from his engagement with that gentleman. He is very intelligent and promises well.

The other native surveyors, Nabee Bux and Thakoor Dass, are both of Lahore, and seem likely to turn out respectably. They were strongly recommended...in the Chief Engineer's office, ... and were selected by me from a number of applicants. They also were entertained on Rs. 30 a month on probation.

Two of the new levels were lost on the voyage from Calcutta to Karāchi, but Walker got sanction to purchase "a very superior standard level" from "the officer in charge of the Baree Doab canal";

It is in my office, and...immediately available for practice, whereas I could scarcely receive an instrument from Calcutta in less than 6 months. ... The first pair of levelling staves... despatched from Calcutta on the 23rd February...reached Kurrachi on the 24th April, and will take at least 3 months more to reach Rawalpindi. In the rains...the delays will be greater[1].

The party was now equipped with "three standard levels by Troughton & Simms from the Punjab canal department, ... incomparably superior in delicacy of level and in magnifying power to ordinary levelling instruments". Walker was equally pleased with the new staves, the first pair of which had been

despatched from Kurrachee...last April, and reached Multan in May. ... It was handed over by the officer in charge of the steamer...to a new freight agent. ... I applied to the Postmaster and the Indus Flotilla freight agent at Mooltan, who gave me to understand...that no such package had reached that station. ... For the previous six months the missing staves had been lying in Mr. Spencer's godowns. ... They...have this day [2nd December] reached my camp[2].

He started work in November 1858, and with Branfill, Carty, and his Indian staff worked northwards from tower stations south and west of Lārkhāna,

whose heights were...deduced by the triangulation over the hills from the tidal station of Manora [45]. They were carried northwards to Dera Ghazi Khan, a distance of 312 miles, over a line which was levelled over independently, station by station, by Major Walker, Lieut. Branfill, and Mr. Carty, the mean of the results obtained by the three observers being eventually adopted as the final value. From...Maru Pir, the point of origin, as far as Kasmor the line was carried along the sides of the principal triangles, and the heights of a number of the principal stations were thus determined. From Kasmor up to Dera Ghazi Khan it was carried over the main road, for no stations had yet been built in this portion. ... Stone bench-marks were, therefore, left at suitable intervals for eventual connection. ...

I determined that Mr. Carty should use the old set [of staves] with which he conducted his levels on the Jogi-Tila Series [75], and that Lieut. Branfill and myself should observe simultaneously to the new staves.

Mr. Carty goes in advance with his own level and set of staves. He is accompanied by a duffadar who measures equal distances...with a chain of 100 links, and by a carpenter who drives in...wooden pins, and afterwards inserts a hemispherical brass brad into the head of each pin for the staves to rest on [160]. ... Lieut. Branfill and I follow, each of us working with our own instrument, and observing simultaneously to the new staves which are placed on the pins already referred to by Mr. Carty.

Regular check was made between the three surveyors, only one major discrepancy being noted;

In no other case has the maximum difference between all three observers exceeded ·02 [feet], while in more than two thirds of the observations it has not exceeded ·01. ... The largest difference does not occur between Lieut. Branfill and myself, but between us and Mr. Carty, which makes me suspect that they are caused in a great measure by the irregularities of graduation of the old staves. ...

We have this day received a second set of new staves, and have no further need to use the old ones. In the course of a fortnight I ought to receive a third set, when we shall each be able to work perfectly independently. ...

There is so much advantage in getting on a road or open plain when the direct line passes through much jungle that we progress faster by so doing, even when we have to make a considerable detour. Fortunately there are good roads near our towers on the west flank, and I purpose to carry the levels along them, branching off...whenever necessary, until we reach the last of the towers. ... Thence we will proceed along the main road, leaving permanent bench-marks at distances of about 10 miles until we reach the towers of the upper section. ...

[1] DDn. 710 (202), Walker to SG., 11-5-58. [2] GBO. Comp. M-9/7; Walker to SG., 2-12-58.

If everything goes on smoothly, I anticipate a rate of...100 miles a month, which would bring us up to Dera Ishmail Khan by the end of this season. ... The work is exceedingly laborious...and hitherto we have not averaged so much as 4 miles a day, though we have been hard at work daily from sunrise to 3 or 4 o'clock in the afternoon, and sometimes later. ...

Breakfast taken during work in the open air has a tendency to cause apoplexy as well as delay. It has consequently become a phenomenon which only presents itself to us on Sundays. Hitherto none of us has been any the worse for the work[1].

I lately visited Jacobabad for the express purpose of reading all I could find on the subject of levelling in the magnificent library of the late General Jacob [IV, 446; V, 45][2]. I found nothing of value in the Encyclopædia Brittanica, nor in the ordinary works on the subject. In the "Aide-Memoire" of the R.E. enough is said to show that the writer was aware of a tendency to unequal refraction from the back and forward staves. He recommends that they should be set up at very short distances from the instrument, and also advises a complete meteorological record to be made at each station[3].

Walker's normal practice was to keep distance between stations from 8 to 10 chains, though greater distances were occasionally allowed. Modern practice restricts distance to five chains.

A constant analysis was carried on of the work of the three independent observers both by the surveyors on the spot, and by the Surveyor General and Hennessey at Dehra Dūn. One of the changes recommended by the Surveyor General was that there should be as much observation carried in the reverse direction as in the forward, but Walker was reluctant to spend the extra time involved ;

Theoretically a circuit system...closing on the original point of departure is the best. But to have adopted it we must either have abandoned our practice of working in concert and thus lose a material guarantee of freedom...from...casual errors, or we must have worked back over the original line of levels, station by station, and thereby have doubled the time. ...

In the field season 1859–60 I therefore adopted a medium course, by which the observers were allowed to remain together, but they were required to level alternate sections [about 4 miles each] in opposite directions. ... This method, ... with Col. Waugh's alternating system, can be worked effectively and expeditiously[4].

At the close of season 1858–9 it was found that the discordance between the spirit-levelling and the trigonometrical vertical angles along the Indus Series varied from + 9 and — 3 feet from station to station. During recess a comparison was made between the height deduced by Tennant's triangulation and that by the levelling of the Sind Railway and Canal departments, the meeting place being "a stone bench-mark...buried in the ground in the vicinity of the 2nd milestone on the road from Shikarpore to Lārkhāna". The difference amounted to 28·68 feet [79], which led Walker to extend levelling operations to the sea,

to obtain a satisfactory determination of the height of their origin above sea-level. With this object I propose that in the next field season Mr. Carty and Ramchand, assisted by recorders Thakoor Dass and Nabi Bux, should level the northern section of the Indus Series from Dera Gazi Khan to Kalabagh, while Lieut. Branfill and I assisted by the two new recorders proceed to the southern section and level from Maru Pir station to the sea [77][5].

During season 1858–9, therefore, Walker and Branfill levelled down to Karāchi ;

Commencing at...Maru Pir in the Larkhana District, ... they levelled over the sides of the triangulation down to the station of Mir Khan—where the triangulation from the south may be said to have fairly entered the plains of Upper Sind—to Karachi. At Mir Khan it was optional for them to proceed either by the route over the hills, or by the river route via Sehwan...and Tatta. Both were very circuitous, but the former was the shortest by about forty miles.

The river route presented greater facilities...and...as it would afford opportunities for connecting together various existing lines of canal levels, and also furnish valuable data for...new canals, was therefore chosen. ...

The levels were connected with the southern extremity of the base-line near Karachi, and...brought to a close on a bench-mark in the harbour of Manora, the height of which, relative to the mean sea-level, ... had been...determined by Lieut. Tennant. It was also the origin of the trigonometrical...heights of the...Great Indus Series. The length of line levelled...during the season was 301 miles.

[1] *GTS.* IV & *Syn.*, I (viii—D). [2] John Jacob (1852–58); d. suddenly at Jacobābād, 5–12–58; *DNB.*; *DIB.* [IV, 448]. [3] ib., 1–1–59. [4] DDn. 594 (325), note by Walker, 25–9–60; cf. 710 (308), Report 1859–60, 5–6–60. [5] DDn. 710 (269–A), Walker to SG., 5–7–59.

The height of Maru Pir as deduced by the triangulation was found to be very closely accordant with the value derived from the levelling operations. ... The discrepancy...between the trigonometrical heights and the...canal levels was...due to an error of sign...made in combining several canal lines. ... After correcting this error a circuit of upwards of 550 miles...formed by the canal and survey levels closed with a discrepancy of only ·11 of an inch.

In the northern section Mr. Carty and Ramchand...carried a line of levels from Dera Ghazi Khan along the east flank of the triangulation up to Sandi, the northernmost station in the plains. Thence they worked along the main road, via Mari and Fathijang[1], to the Chach valley, closing on the southern extremity of the base-line near Attock. The...line...was 379 miles, of which fully 100 miles lay in the rugged and difficult ground of the Rawalpindi District.

The entire length of the line...connecting the Chuch base-line with the sea is 939 miles[2].

Carty sent in his first report after completing the line from Dera Ghāzi Khān to the tower of Ajmad Sindi, just north of Dera Ismail Khān ;

My eyes suffer so much from the glare reflected off the sand...that I find it difficult to bring up my day's work by candle-light, and 'tis only when work is hindered by stormy weather that I have an opportunity of informing you of the results of my labours. ... Excepting Sundays the work has gone on day after day since the 18th November.

The first five sections...were measured with No. 2 level leading, and my instrument No. 3 following. This arrangement, continued for 50 miles, was made to afford Ramchand practice, ... and whenever I had the chance I used to examine his focus and cross-levelling, and occasionally bring him back to remeasure...where our differences were large. I found that Ramchand, whether working first or last, gave me results that I could depend on, consequently from the 9th to the 14th sections I led the work, as Ramchand doing so interfered with the progress. ...

The pace I work at would prevent all attempts at copying, and several differences such as ·008, ·010, ·012, which Ramchand's work shows, and of which he always apprises me at the time, ... make me confident that in Ramchand I have as trustworthy an aid as I require. ... I...recommend him as a workman whose results are not likely to be found materially wrong. ... I wish I could speak as favourably of the two recorders. Nabbi Bux, if hurried, ... is occasionally found stumbling. Thakoor Dass is if anything more careless than he was last year. ...

I have noticed that where the rays to back and fore stations are unequally influenced—one lying over moist ground or having a sandhill in its ray, or passing through a narrow gap cut in...jungle...—there Ram Chand's values and mine differ however short the distance may be. ...

I am rather anxious about the line to Sandi which was levelled over in 1856. Lieutenant Basevi at Dara Deen gave me the difference between that town and Ahmad Sindi as 10·51 feet. If I again get the same I shall be accused of fudging, if I get a large difference I shall be condemned as a bungler. Either horn of the dilemma is unpleasant. ...

Should the Surveyor General's orders regarding my working from south to north and the reverse reach me at Sandi, I can easily carry them out by alternate sections. ...

The tent you were kind enough to send me...is still holding out, and has been very useful from its roominess and loftiness. ... There was no tent for sale on all my journey down[3].

The whole line from Karāchi to the Chach base-line, some 960 miles[4], was thus completed between November 1858 and May 1860, at a cost of Rs. 42 per mile.

The error in...height of the Chach base-line by...triangulation from Calcutta over...1,371 miles is found by the levelling...to be about 16 feet. But the error in...the triangulation...from Karachi over...710 miles is only 2·30 feet. Both are in excess of the levelled value.

In addition to determining heights necessary for our operations, we were careful to fix numerous bench-marks...for the use of the public, and to connect all canal and railway marks within range. ... In Sind alone upwards of 250 marks have thus been fixed. ... The Superintendent of Canals is now drawing up a Map of Levels in Sind based on our operations. ...

To guard against errors of unit...a standard bar was made up by the Deputy Surveyor General with which the staves were compared at suitable intervals during the field season[5].

During season 1860–1 spirit-levelling was carried along the south bank of the Sutlej by Branfill, Carty, and Ramchand, starting from a bench-mark of the Indus Series a few miles below Mithankot. As principal stations of the Sutlej Series were not ready when work started, the stone bench-marks were connected up later by Ramchand [53]. The line of levels was carried through Ferozepur, and then along the grand trunk road to Ambāla, completing 455 miles during the season[6].

[1] Mari-Indus, opposite Kālābāgh ; Fatahjang, 25 m. w. of Rāwalpindi. [2] *GTS.* IV & *Syn.* I (X–XI—D). [3] DDn. 710 (307), Carty to Walker, 6-1-60. [4] as compared with 710 m. by triangulation. [5] DDn. 594 (325), Note by Walker, 25–9–60. [6] *GTS.* IV & *Syn.* VI (IV—H).

In November 1860 Walker submitted a studied note[1] on the spirit-levelling operations, describing the instruments and apparatus used and the procedure followed, with instructions for future guidance, and, writes Burrard in 1910,

in the long period of levelling from 1888 to 1909...one fact stands out clearly, and that is that in 1858 the Indian levelling was started upon correct and scientific lines. ... We owe much to General Walker who was the founder of Indian levelling for the care and the thought he bestowed upon the subject before he initiated the field work [3].

Burrard gives the following summary of the levelling of the early years ;

The principal system of spirit-levels is that of which the datum is the mean sea-level at Manora Point in the harbour of Karachi. A line of which the total length is 1,021 miles, the direct distance being 712 miles, extends from Manora to the Chach base-line...traversing the valley of the Indus, and passing through the portion of the triangulation of the Great Indus series which lies wholly in the plains.

Another line, starting from the first, ... traverses the Sutlej valley up to Ferozepore, then turns to the south-east, and after connecting the Gurhagarh and the Rahun series, and the Dehra Dun base-line, passes down the Great Arc to the Sironj base-line.

From the Great Arc two lines have been carried to the east and south-east, which close respectively on the Sonakhoda and the Calcutta base-lines. ...

A connection has been made with the Kidderpore Dock at Calcutta, at which tidal observations have been regularly taken for some years, and the mean level has long been assumed to be identical with that of the sea in the Bay of Bengal, and has been employed as the datum of the trigonometrical heights in...Bengal. Its value is given by the spirit-levelling...as 2·33 feet above the mean sea at Karachi, but the mean level at Kidderpore is that of a tidal river, ... which is necessarily higher than the sea into which the river discharges [69–71].

In all the more modern chains of triangles in which the vertical angles were measured at the time of minimum refraction [64] the...heights agree very fairly with the value obtained by the more exact process of spirit-levelling. ...

On the Great Indus Series the two sets of results were worked out independently in the first instance, and on comparing them together it was found that in the southern section there is a gradually cumulative tendency on the part of the trigonometrical values to be too great, the maximum excess being 8·7 feet. ... From that point onwards there is a gradual convergence, ... and at the terminus the trigonometrical value is 3·2 feet below the spirit-levelled. ...

But, on some of the older series which were executed at a time when it was customary to observe the vertical angles at any time of the day, and even during the night, errors of as much as 100 feet have occasionally been met with [66–7][2].

Reduction, adjustment, and dispersal of errors were carried out by Sir Sidney Burrard, 1908–9, from eleven tidal stations ignoring any situated in estuaries or narrow waters. His detailed results line by line appear in volume XIX of the *Account of the Operations of the Great Trigonometrical Survey of India*, with the remark that "although the accuracy of Indian levelling may in places be open to criticism, yet —...as a whole—it is a great geodetic operation...that will continue to be of interest for centuries if only the bench-marks are preserved"[3].

The lines first run were

No. 43, Karāchi-Tatta, 1859-60—No. 53, Tatta-Shikārpur, 1858-60—No. 54, Shikārpur to Murghai via Kashmor, 1858–9—No. 55, from Murghai, just south of Mithankot, across the Indus opposite Dera Ghāzi Khān—17¼ chains across main channel—then up the left bank of the Indus to Darya Khān opposite Dera Ismail Khān, and through Miānwāli to Mari Indus ; then north-east away from the river...to Fatahjang, ... and...north-west to Chach base [79].

Carty and Ramchand, 1860–1 ; line 57, Murghai to Ferozepur, crossing Indus below Mithankot, main channel 28 chains wide. Line 61, Ferozepur to Meerut via Ambāla[4].

In combining the trigonometrical with the levelled heights the latter were taken as correct and final. For stations not directly connected by the line of spirit-levelling, height was deduced by trigonometrical means from the nearest station on the levelled line[5]. Numerical values of all heights along the lines of spirit levelling are given in the latest editions of the Survey of India *Levelling Pamphlets*, published by degree sheets from the year 1911.

[1] DDn. 710 (336), 10-11-60; pub. Roorkee, 1868, ono. Lib. F. f. 57 & H. e. 4; lecture read 10-6-64, *RAS.* (*mn.*) XXIV, 1864 (218-9); *MRAS.* 33, 1863-4 (103-14). [2] *GTS.* XIX (pref. xii). [3] *GTS.* II, ch. xiii (155-6); 9 stations, *GTS.* XIX, Table XXXIX; 2 other stations, Table XLII. [4] *GTS.* XIX, A & B (pref. xi); ch. 7 (3–4); 9, appx. (451). [5] *GTS.* II (pref. xiv).

CHAPTER VII

SNOW PEAKS

Early Observations — Nepāl & Sikkim, 1845–51 — Kumaun to Kashmir —K 2, Discovery & Name — Computations — MOUNT EVEREST : *Height — Identity & Name.*

THE marvel of the great snow range of the Himālaya as viewed from the distant plains has been enthusiastically described by many early travellers [I : 67–78 ; IV, 243]. Though Rennell fixed the positions of many peaks "by good bases" he could not determine their heights, and was content to map them as conventional sugar-loaves, with an occasional "high mountain seen 135 miles off" [I : 76–7 ; pls. 5, 8, 14]. Henry Colebrooke, the Sanscrit scholar, made the first recorded observations for height from Purnea in 1790, deducing 26,000 for an unnamed peak [I : 77]. Charles Reynolds would have seen the mountains during his excursion through Meerut, Hardwār, and Rohilkhand in 1793–4 [I : 55], and the artistic display of ranges and peaks in his map of Garhwāl and Kumaun looks far from haphazard [II, pl. 3].

The first regular survey of peaks and their heights was made by Charles Crawford who spent a year in Nepāl, 1802–3, and brought back a table of distances and altitudes of the principal peaks, with profiles of the snowy range, distinguishing the peaks observed [II, 70–2, 392][1]. He then ran a survey through the plains from Purnea to Rohilkhand sketching in the distant panorama [II, 27].

Between 1808 and 1812 Robert Colebrooke the Surveyor General, Benjamin Blake, and William Webb, made observations from the plains of Gorakhpur and Rohilkhand, from which Henry Colebrooke computed the height of Dhaulāgiri at 26,862 [II, 87 ; V, 65]. The British occupation of Garhwāl and Kumaun in 1816 gave Hodgson, Herbert, and Webb even greater opportunities, and Webb's heights, including Nanda Devi 25,669, attracted wide interest [III, 26–48 ; pl. 6][2].

In September 1834 Everest and Peyton took observations to the Bandarpānch–Srikānta group from Banog, Kedarkānta, and the Chaur, in extension of the Great Arc [IV, 38, 435][3], and during 1841–3 Du Vernet fixed "Bandarpunch...Jaonli, ... Kedarnath, Badrinath, with others", from his North Connecting series [IV, 71][4].

NEPĀL & SIKKIM, 1845–51

In 1845 Logan and Walker were deputed to start the longitudinal series that was to follow the foot of the hills and connect the heads of the several meridional chains without infringing the Nepāl border. The Surveyor General called on them to take every opportunity to observe the snowy peaks [17, 19] ;

> The lofty snow peaks situated north of Nepal are the most stupendous pinnacles of the globe. Their heights and relative elevations are therefore most interesting desiderata, ... and should form prominent objects in the geodetical operations now in progress. ... The positions... can be laid down with the greatest chance of success from the stations of the North Longitudinal Connecting series which...will afford the longest base for determining their distances.
>
> Their heights may also be deduced with the greatest accuracy from the vertical angles taken at the shortest distances from them but, as the refraction adopted in reducing the

[1] Buchanan-Hamilton (346, pls. ii–vii). [2] Webb's chart with list of 25 peaks, MRIO. Misc. 6–O–21 [III, 46 n.4 ; IV, vi]. [3] GBO. Comp. F-18-11 (820–1829) ; Peyton making a panorama sketch [91]. [4] DDn. 452 (7) ; Report, 1841–2.

observations will form an important element in the computations, it is desirable that vertical angles should be taken at a great variety of distances [64, 90]. ...

P.S. In observing unmarked points there is always a risk of mistakes, because the appearance of a peak varies so much in different aspects, and the only way of efficiently checking the identity of the point is to take frequent observations at short distances apart [95, 227][1].

Neither observer succeeded in getting any observations to the peaks, either that season or the next, for clear views could only be had in the late autumn, and they never had the towers ready so early [84]. Logan writes that

a considerable extent of the snowy range was seen on several occasions during the months of October and November last, but since that period I have never been able to see even the lower range of hills with the exception of the 16th of March, when the nearest ones were seen for about an hour after sunrise[2].

Walker wrote that he "had a fine view of the snowy range for two days n December last after a heavy fall of rain, but have not since seen the snows"[3].

Armstrong was the first to have any success from Bihār. On taking charge of the Gora series in September 1847, he had been deputed to lay out the tower stations of Logan's section of the longitudinal series along the northern borders of Champāran and Gorakhpur [17–8]. He was first to concentrate on observing the peaks from the stations from which Logan had been unsuccessful, and though his 15-inch theodolite was inadequate for the principal triangles it was fitted with a special level for the peak observations. The snow peaks, writes Waugh,

are said to be only visible during the months of October and November, and early in December. It will therefore be desirable to reach the ground...early. ...

You ought to commence...at some station a little south of the north extremity of the Chendwar series [pl. 4], ... proceeding regularly onwards, and visiting every alternate station for observation, taking the precaution to watch carefully on your march any change of aspect in the peaks so that no doubt of their identity may exist.

A sketch of the appearance of the Himalayan range should be taken at each station of observation, either by means of a camera obscura, ... or by projecting...to scale the observed altitudes and azimuths of the principal peaks and sketching the remaining features by eye [84–5, 88–9]. ... Treat all the triangles as spherical [35]. The vertical angles should be taken between 2½ hours and 3½ hours p.m., and such only as are thus taken at minimum refraction ought to be employed in deducing the heights, except in the case of very distant peaks visible only at dawn or in the evening.

To obtain the proper factor of refraction, ... take a few morning and evening vertical observations...to one or two of those eminent peaks which are visible, also at 3 p.m., so that the difference between the altitudes observed at various periods and those at *minimum* refraction may give the change...due to the period of observation [64, 84, 90]. ...

Four verticals, two face-right and two face-left, will suffice for each point, but when you are detained for more than a day at any station, the verticals, especially to the highest peaks, should be repeated[4].

On 13th and 14th November 1847 Armstrong took angles at Sawājpore station, a few miles north of Muzaffarpur, to a snow peak which he called (b) ; the whole range "was perceptible but rather indistinct for intersection"[5]. He got another horizontal angle from a second station, but no other confirmatory horizontal or vertical angle, and all the observations at these stations were rejected at the final computations [91]. This peak (b) proved identical with that observed as "*gamma*" by Waugh and Lane during this same month from the east [83–4, 91]. In reporting on Armstrong's work the Surveyor General wrote that

his proceedings were very successful, for during the favourable period he laid down all the principal points on the range visible from his stations. Among these are all the great peaks formerly measured by Colonel Crawford, and described in Hamilton's *Nepal* [II, xxvii ; V, 81, 91]. In addition to these heights he also obtained observations to some lofty peaks further east, apparently at...the head of the Kosi River.

His observations to one of these mountains indicate an altitude higher even than the great Kanchanjinga, amounting to no less than 28,799 feet, but on account of the great distance ...the observations require further verification from stations less remote. This verification I anticipate will be accomplished by Mr. Peyton during the present season [84–5]. ...

[1] DDn. 499 (110–3), SG. to Chendwar & Maluncha, 26–8–45. [2] DDn. 496 (135), 18–5–46. [3] DDn. 514 (227), 20–5–46. [4] DDn. 723 (36), 25–8–47. [5] GBO. Comp. A–11–67, angle-book NE. Longl.

Observations were taken to the snowy peaks from 7 stations whereby were determined all the principal points in the range over an extent of 180 miles[1].

Armstrong's seven stations lay in Champāran between the Hurilaong and Chendwar series and at most of them he got, between 10th November and 26th December, complete sets of angles, both horizontal and vertical. The weather was very fickle, ... never continuing clear for any lengthened period and, though...I made all the haste I could in my marches, ... in most cases...I was disappointed.

At Teharwa, ... though I waited there three days, I was...compelled to leave...without a single observation. At the next station, Ramnuger, however, the weather was more propitious, but the tower was in such a state of ruin that I was unable to make any arrangements for putting up the large theodolite, and was compelled to be contented with...the 11-inch, with which I could only secure a set of horizontals in the early part of the day. ... The hills have since never been visible[2].

During the summer of 1847, before Armstrong had started in Bihār, the Surveyor General was himself making secondary observations in the neighbourhood of Darjeeling, from which he fixed the great peaks of Kangchenjunga[3]. He had originally deputed this work to the Maluncha series, but after Walker's death at the end of April, he took charge himself, assisted by Lane and William Rossenrode. The political officer, Dr. Campbell, had at first reported that "the Sikkim Rajah objects to the resort of European gentlemen into his territory, even for recreation and exercise", but Waugh eventually obtained unofficial permission to visit Tonglo, a commanding point to the west.

With the assistance of Lane he found three stations inside British territory from which good connection could be made with the principal stations in the plains, and form good bases with Tonglo for the intersection of the great peaks[4]. Lane reports that after the close of the rains

we fairly took the field about the 10th or 15th September. ... Rossenrode proceeded to the plains stations. ... Lawrence to Tonglo, and myself to Senchal hill station. Shortly after, you yourself proceeded to Tonglo to observe the final angles. ...

I observed the final angles at hill stations Darjeeling, Birch Hill, and Senchal hill. This, however, was not effected, owing to clouds interfering, until about the 15th November, when... Rossenrode...and myself immediately started for Dhum Dangi in the plains, ... sub-assistant Lawrence being left at Tonglo Hill...to ensure the party being undisturbed by the suspicious and ignorant hill tribes while exhibiting their signals to the stations in the plains [473][5].

From these operations were obtained the exact position and height of Darjeeling and of the great mountains Kangchenjunga and Chumalhari, and a few rays, though without vertical angles, to the great peaks to the west, one of which "*gamma*" was later found identical with Armstrong's (b) [82]. Waugh found that

the western peak of Kanchunjinga attains an elevation of no less than 28,176 feet above the sea, which far exceeds what has hitherto been conjectured. The mountain of Chamalari... which Turner estimated at 30,000 feet [1 : 394] is proved to be only 23,929 feet[6].

Various local authorities suggested that the Surveyor General had been misinformed as to the identity of Chumalhari, but they eventually admitted that he had been right[7]. A chart published at the same time showed no fewer than 73 peaks observed during these operations. Kangchenjunga was hailed as the highest mountain in the world, 28,146, and Waugh kept quiet about Armstrong's (b)[8].

Walter Sherwill, who was on survey in the Darjeeling hills shortly after [186] comments on the plumes of snow that are a familiar feature of Himālayan peaks ;

A current of air passing over the warm valleys of Nepal is driven up the face of the snowy range ; a portion of this current...as it passed over the summit of Kunchunjinga is condensed by the bitterly cold air on its north-west...face and thus brought to sight. An indigo planter who has lived for 40 years in the plains, and in sight of Kunchunjinga, declared that nothing would convince him that the mountain was not an active volcano [II, 87][9].

---

[1] DDn. 462 (265–307), SG. to Mil. Dept., 15–1–49. [2] DDn. 496 (247), Armstrong to SG., 15–1–48. [3] Mason's spelling (Kang = Ice) preferred to earlier Kan—or Kin ; Mason (37–41); cf. Burrard & Hayden (28–33). [4] Hills, Darjeeling, Birch Hill, Senchal ; Plains, Bhandarjula, Thakurganj, Dumdangi ; chart facing p. 678, *JASB.*, XVII, 1848. [5] DDn. 513 (105), Lane to SG., 23–5–48. [6] DDn. 462 (265–307), SG. to Mil. Dept., 15–1–49. [7] *JASB.*, XVII, Nov. 1848 (676–7) from Dr. Campbell. [8] TS. 15 ; NE. Longl. (17–27) ; "Secondary mountain trgn. incl. Darjeeling Series". [9] *JASB.* XXIII, 1855 (57).

On resuming work on the longitudinal series in November 1848 [18], Logan worked west through Gorakhpur from the head of the Hurilaong series, and by changing his tactics got successful observations to the peaks from three stations.

The unhealthy nature of the country...prevented me commencing...operations until the 1st November, at which period the snowy range has generally ceased to be constantly visible. ... Aware from past experience that there was little hope...if I waited until the towers were ready, ... I determined...to take the large theodolite with me at the beginning of the season. ...

A strong and substantial pin was driven two or three feet into the ground to mark the centre of the pillar to be eventually erected. Three pickets of the same length were driven to the surface of the ground, and on them the stand of the instrument was placed, a circle three inches wide and 5 or 6 deep having been dug outside the three pins so as to isolate the instrument from the observer. ...

On the morning of the 6th [November]...I succeeded in getting a very good set of observations at the station of Anarkali [nr. Bahraich]. ... At Toolsipoor [50 m. east]...on the... 20th and 21st I succeeded in getting a set of most satisfactory observations to peaks extending over a range of two degrees of longitude.

From this time to the 13th December the snowy range was not visible from any of the stations...but betwixt the observations, the peaks being most distinctly seen from an hour before sunrise to 9 or 10 o'clock, by which time they got obscured by clouds.

I attribute...my success to the zeal of my acting tindal, who succeeded in keeping the classie in charge of the instrument...constantly on the alert. ... By this means I was enabled to have the instrument levelled and ready for the observations before daylight and to commence the angles as the first rays of the rising sun lighted up the summits of the mountains. An early visit to the observatory likewise enables the observer to ascertain on which of the peaks the rays of the sun first appear and, as those first illuminated are evidently the highest, he is able to devote more attention to them.

The peaks not being situated on one ridge, but on several, it is essentially necessary...to make careful sketches as frequently as possible. Unless this is done, one peak will...be mistaken for another. ... I am indebted to Mr. James [J. O. N.]...for a set of very accurate and masterly sketches which he generally made while I was taking the angles. These...rendered the identifying the peaks on arrival at a new station a matter of certainty [82]. ...

I...succeeded in determining by symmetrical triangles the heights and positions of every prominent peak betwixt the meridians of Hurilaong and Karara [pls. 3, 4][1].

At the close of season 1848-9 Logan took his party to recess at Mussoorie where he and Hennessey computed preliminary positions and heights of the peaks observed [90]. During his next season in the *tarai*, 1849-50, he observed from the head of the Amua series to Nanda Devi and other Kumaun peaks [pls. 3, 4].

When Peyton took up work on the longitudinal series in 1848, working east from the head of the Chendwar series [19], the Surveyor General directed him to make every effort to observe the peaks ;

Last year the snowy range remained visible up to about the 18th December, after which it was not seen again till the beginning of February. ... It would be advisable to obtain...a memo of Mr. Armstrong's observations. ... These will enable you to direct your instrument to the precise points he intersected [91]. ...

The great difficulty hitherto...has been...that the approximate series is in process during the favourable season, and when the final work commences the hills are invisible.

As a remedy he suggested that observations should be taken to the peaks during reconnaissance before construction of the towers [82, *sup*]. After deciding on the centre point of the intended tower, observations should be taken from that point, taking azimuths from a nearby referring mark, which should later be included with the final observations taken from the top of the tower.

I...recommend your...obtaining...the positions of...peaks "delta" and "gamma" of the Darjeeling series. ... I particularly wish you to verify Mr. Armstrong's peak (b), ... the highest yet ascertained. Observations at Harpur on this peak will be very valuable [85, 93]. His peak (a) also requires to be well verified because the two heights deduced are very discordant [82]. ...

You should observe at different hours to try refraction. 3 to 4 p.m., or the time of minimum is the best period, but 8 or 9 a.m., and sunrise observations, are also valuable on the same peak for the sake of contrast [82, 90][2].

[1] DDn. 593 (79), Logan to SG., 7-7-49. [2] DDn. 515 (166), SG. to Peyton, 21-9-58.

Peyton had little success, and after his handing over to Nicolson Waugh directed the latter to give priority to the peaks ;

The want of observations last year to the snowy peaks disappointed me much. ... The great element of success appears to be careful watching. Men should be on the look-out early in the morning to apprize you of the visibility of the range. You should be in the observatory before sunrise, and all prepared to commence horizontal angles as soon as it is light. The vertical angles may be taken from 8 to 10 o'clock a.m. ...

One of Mr. Armstrong's peaks appears to be the highest Himalayan mountain, and requires verification, having only a single determination of distance and one of altitude, the observations being taken at a great distance [82, 84, 91].

Scrupulous care is necessary to prevent confusion of identity, as well in the observations themselves as in the recording and lettering. ... You can use the same letters or begin a new series of your own, giving in the angle-book the synonym letters used by Mr. Logan and Mr. Armstrong [92]. ... Concentrate your attention entirely on the snowy range east of that meridian [Chendwar]. With a powerful telescope you will discover little knobs and points on the peaks. The highest and most remarkable of these must be taken as points of intersection, carefully drawing their shape to preserve them in recollection. It sometimes happens that peaks are double or treble and lie in a north and south direction. ... Great attention is required to prevent confusion in such cases. ... Consult Mr. Logan on the subject, for his observations have been remarkably successful [84][1].

Nicolson reached Madanpur of the Chendwar series on 3rd November 1849, and on the evening of that date, after a shower of rain, a set of observations with the 12-inch theodolite was obtained to some of the snowy peaks. The party arrived at Bulakipur on the 5th instant, and remained there for 12 days. ... The snowy peaks, ... however, were not seen again till the 27th, when horizontal and vertical angles were taken to them with the large instrument at Jirol station about 32 miles east of Bulakipur[2].

[In December] two sets of observations, horizontal and vertical, were obtained to the snowy peaks—the peaks (b) and (a) of Mr. Armstrong's series being among the number—at Mirzapur station on the 5th, 6th, and 7th instant, and a set likewise...to the same points at... Janpati, Ladnia, and Harpur, between the 8th and 10th of the month, after which period the snowy range was never seen again[3].

In January 1850 he observed at Baisi and Mania stations at the head of the Maluncha series [pl. 4], and observations from six of all his stations were used in the final deductions of position and height of Mount Everest [93].

Waugh made one last attempt to gain permission to enter Nepāl, suggesting that Government might welcome "the fixing of...Khatmandoo in an accurate manner" ;

When I was at Darjiling in 1847, Mr. Hodgson[4]...thought there would be no difficulty in obtaining the sanction of the Nepal Government to an undertaking of this kind, and the recent visit to England of H. H. Jung Bahadur will...facilitate the measure. ...

During the progress of the operations...along the northern frontier of British India, opportunities have occurred of determining the positions and elevations of the principal peaks ...from Cashmere in the west to Kanchinjunga and Chamalari on the east. ... The results... may be pronounced as accurate as modern science can achieve, every refinement having been introduced, and the results calculated in accordance with the known figure and dimensions of the earth. ... The results will be more exact...as the distance is shorter, and the difference of elevation between the station of observation and the object is less. ...

Along the whole extent of the Nepal frontier the snow range is very distant, and the stations of observation low. ... Much more accurate altitudes could be obtained if the triangles were extended into the Nepal mountains, whereby the observations...would be verified, and the names of the principal peaks...might be ascertained[5] [92].

Permission was not granted[6].

The Surveyor General urged the Assam party to observe the snow peaks of Sikkim and Bhutān from further east, and wrote to Nicolson at the end of 1855, after the earlier observations had been computed out ;

I wish to gather together for publication...in one view the positions and heights of the principal Himalaya mountains. The materials already collected by me extend from the Safed Koh between Kabul and Peshawar to...Chamalari east of Darjeeling [91–2]. ...

[1] DDn. 493 (243), 3-10-49. [2] DDn. 602 (8), Report for Nov., 1-12-49. [3] ib., for Dec., 1-1-50. [4] Brian Houghton Hodgson, Resdt. in Nepāl 1823–43 (III, 525), *DNB.* ; *DIB.* [5] DDn. 542 (236–7), SG. to Nepāl Resdt., 5-7-51. [6] Permission for GTS. opns. in Nepāl granted 1903 and 1953 [93, 95].

During the three seasons the Assam Longitudinal series has been in existence...no notice whatever has been taken...of the fact of there being any distant peaks to observe. ... I should like to know whether there are any snow peaks east of those I observed from Darjeeling, and if there are what chance we have of fixing them[1].

Nicolson replied that though he and his officers had got occasional glimpses of Kangchenjunga and high peaks further east, these had not allowed of successful intersection. Waugh wrote again after Lane had taken over charge ;

You are aware of the great interest which has been aroused in the case of Mount Everest. If you have an opportunity of investigating the real native name of that stupendous pinnacle... it will be a great acquisition. ... You yourself observed Mount Everest from Doom Dangi and Banderjoola near the origin of the Assam series, but you took no vertical angles [83]. It would be extremely valuable to rectify that omission, and...your verificatory observations will be very highly appreciated. ...

If you retrograde to Darjeeling, ... I wish you at the end of September and beginning of October, to revise all observations from Senchal and Tongla if possible, ... As Doom Dangi is near Titalia, you may be passing that way when the peaks are visible. ... I append a list of all the azimuths at that station and at Bandejola, as well as Menai[2].

Lane was never able to make these observations and it was not until 1880–3 and 1902 that opportunity came for further work on the peaks of Nepāl and Sikkim.

The ms. General Report of the North-East Longitudinal series contains a long professional note on these observations to the snow peaks. The instruments used—from 15-inch to 3-foot—were almost as varied as the observers were numerous.

KUMAUN TO KASHMIR

The peaks viewed from Mussoorie, Landour, and Simla had long been familiar, and their profile had been faithfully sketched by Herbert, Webb, and Peyton[3] [III, 37, 39–40, pl. 6 : V, 81 n.3, 91]. The first G.T.S. fixings by Everest himself in 1834 [IV, 38, 435] and by Du Vernet during 1841–2 [IV, 71] were supplemented by Renny and Peyton when they revised these western triangles during 1850–1 [21]. The peaks thus fixed extended from beyond Bandarpūnch on the west to Api on the Nepāl side of the Kāli River [pls. 3, 4][4].

A wide field of new peaks was opened up after the Sikh war, and there was no longer the political barrier to restrict the movements of the surveyors, as still forbade their entry to Nepāl and Sikkim. Du Vernet now carried the North-West Himālaya triangulation through Sirmūr and westward to the borders of Kashmir, fixing "upwards of 50 snow peaks" from the principal triangles[5]. Waugh was much disappointed that Logan got no view of the celebrated Nanga Parbat of Kashmir but James' extension to Peshāwar gave Tirich Mir in Chitrāl, and several points of the Safed Koh and lesser peaks to the south were fixed from the Great Indus series [47 ; pls. 3, 5].

Magnificent work was done by Du Vernet's assistants who carried their minor triangulation and planetabling to the highest accessible peaks and ridges [5, 201–8], crossing the snowy range at several points, and fixing a multitude of points from the upper Sutlej to Chamba. They were not able, however, to get any observations to Kāmet, 25,477 ft., which had been fixed by Peyton in 1850–1 by only two rays, and the Surveyor General, being anxious to obtain a more exact position and height for his final summary [85], directed Keelan to visit Kumaun on his return from the Rahun series in 1857 [50] in order to determine

the position and altitude of Kamet, or Ibi Gamin of the Messrs. Schlagintweit [87]. The position is laid down...in the Kumaun map supplied...by Mr. Batren and Captain Strachey [187–8]. These gentlemen worked on the basis of the Atlas points. The position is not likely to be far wrong relative to the G.T.S. points, but it must not be supposed to be rigorously exact. ... It will be necessary to advance a series of triangles...from which the peak can be observed[6].

[1] DDn. 592 (356), 16–11–55. [2] DDn. 718 (A–1), 20–10–56; similar lists were sent to the Schlagintweit bros. [145–6]. [3] cf. frpce. *PP.* 14. [4] *GTS. Syn.* XXXV (viii–xiv), Burrard discusses heights Bundarpūnch. to Kedarnāth. [5] ib. vii (liii—C). [6] DDn. 157 (3, 7–8), 3–3 & 4–5–57.

This duty was assigned to Lawrence Clarke, who set out from Dehra Dūn on 13th of May, but owing to the disturbed state of the country and the possibility of trouble in Kumaun, he was recalled and the project abandoned [482][1].

It may here be noted that this name Ibi Gamin, which is now generally adopted for the lower, north-east, peak of Kāmet, is said by Montgomerie to have been first used for the actual peak by the brothers Schlagintweit; "they having most probably mistaken a hillman's broken pronunciation of *Tiba Kamet*"[2] [147].

A new field was opened up when Montgomerie led his party into Kashmir in 1855, and the Surveyor General invited his attention to the

determination of the heights of the great...mountains, especially those appertaining to the Indian Caucasus [1 : 67], and Karakoram ranges. This is too fascinating a pursuit to require being urged. ... I have further to point...to the desideratum of fixing the Nanga Parbut...as well as other celebrated peaks beyond the frontier [86, 223][3].

With his report for 1855 Montgomerie submitted a chart showing that

a large number of perpetually snow-covered peaks have been laid down. The computations... greatly alter the position of these peaks as given in the old maps, and make out the whole of that portion of the Himalayas to be much higher than it was thought to be [89]. Many of the peaks...are above 20,000, and the highest peak of Ser and Mer is 23,400; Hugel [IV, 450] and Vigne [IV, 472] make Ser and Mer 20,000. ... Further to the north the Nanga Parbat turns out to be 26,700; Bates and Vigne make the Nanga Parbat 20,000 above the sea. The mistake in the case of the latter is remarkable as its position was tolerably well known, but Ser and Mer and the whole of the Brahma range were out from 15 to 30 miles in longitude [pls. 3, 5, 6][4].

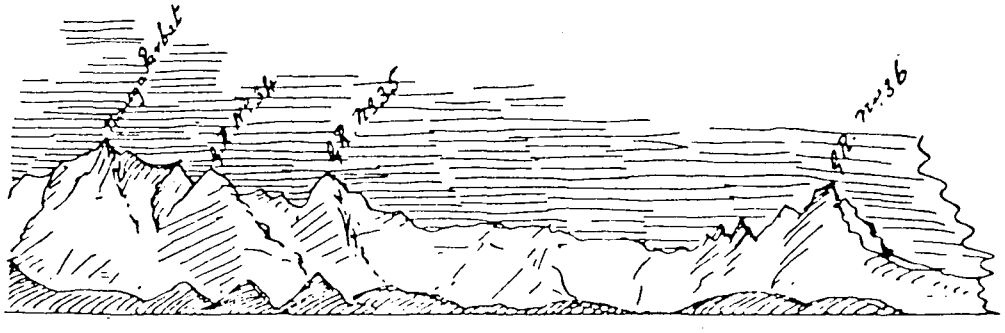
The 17 peaks given by this past season's work include...all the remarkable peaks on the left bank of the Indus that were not laid down by the North-West Himalaya series [86]. The snowy peak in the Pir Panjal marked as (a) in the records of the N. W. Himalaya series was chosen for one of the principal stations of the Kashmir series. ...

The results may assist in showing what reliance can be placed on the observations to an inaccessible snow peak—Snowy Peak (a), or Moolee H.S. [222 n.5]— ... A difference in height of 18·2 feet—in latitude...of about 21 feet—and in longitude of about 5 feet. The coordinates in fact agree as well as they possibly could, when the effects of refraction and the changing shapes assumed by the snow are taken into consideration. ...

Ser and Mer, Kolnarwa, Didyum or Moolee H.S., Baltal, Harmook, and Nanga Parbat... have for a long time been the landmarks...of the country. ... The common sides...agree very closely. The heights...shew but small difference inter se[5] [223].

During 1856 the party fixed position and height of 36 snow peaks;

Nanga Parbat has been determined...with a 14-inch...theodolite from 11 principal stations at distances varying from 43 to 133 miles, and at heights varying from 7,700 to 16,000 and odd feet. ... The mean height of this noble mountain is 26,629 feet above the sea. No peak for 60 miles comes within 9,000 feet[6].



Ser and Mer, twin giants—the former white and the latter dark because it is too precipitous to retain much snow on the Kashmir side—also...called Nana Khana, as well as Dum Hiry

[1] DDn. 692 (301), Report, Rahun Ser., 1-8-57. [2] *tibba* = hill; DDn. 53 (381), TGM. to STS., 23-7-62. [3] DDn. 692 (152); 11-1-55 (18). [4] modern values, Ser & Mer, or Nun & Kun, 23,410; Nanga Parbat, 26,620. [5] DDn. 692 (11) Report for 1855, 20-3-56. [6] details of obsns., DDn. 716 (23), 27-1-57; (64), 26-3-57; 696 (277), report for 1855–6; sketch by TGM. from Haramukh, angle-book OBO. Comp. F—13–63.

and Pajah Hug, besides other appellations. These peaks and all others from No. 1 to No. 12 are well known to those sportsmen who shoot ibex in the Wurdwun valley[1] [226–7 ; pl. 6].

Montgomerie pointed out that his heights might be affected by deflection of the plumbline and by falls of snow [137]. "The refraction...has...been determined practically from our own reciprocal observations between principal stations"[2] [65, 90]. In a note to the Deputy Surveyor General covering a list of heights for mapping purposes, he points out that they were still based on the value brought up by triangulation from the Kidderpore tide-gauge [66, 80]. He adds that

hitherto the Nanga Parbat, which is also called Dayarmar[3], has been put down as 19,000 feet above the sea, ... rather a bad shot for conjectural geography.

During my three days residence on the snowy mountain Haramook, at upwards of 16,000 feet above the sea, I had several fine views of the Karakoram Range to the north of the Indus. Amongst others, two very fine peaks were visible beyond the general outline of the Mustagh and Karakooram ranges. These two peaks promise to be high ; they were but faintly defined against the sky, being probably about 150 miles from me [89 ; pl. 6][4].

He dubbed these two peaks K 1 and K 2, but no second shot was got to them until July the following year, when Brownlow observed them from stations further north and the height of K 2 was found to be some 28,000 feet [89, 229][5].

In his instructions to Shelverton and Johnson for observation along the Indus between Skardo and Leh[6], Montgomerie directs that

the principal vertical observations are to be taken twice on each face...between...1 and 4 p.m., and every day...if weather permits. ... All snowy peaks to the north of the river Shyok, and to the north of the Indus below the junction of the Shyok, will be denominated K 11, K 12, ... etc. All other peaks to be called B 19, B 20, ... etc. ...

Time must be noted when verticals are taken to the snowy peaks. ... The clouds rarely permit the snowy peaks to be seen after noon, but it would of course be advantageous to take them near minimum refraction. ... Peaks to the north-east of the Indus to be called I 1, I 2, ... etc., and those peaks at the head of the Indus to be called R 1, R 2, ... etc. All peaks to the south of the Indus on the Zanskar (or Zaskar) side to be called Z 1, Z 2, etc. ... K 2 should always be observed[7].

With his report for 1860 Montgomerie appends a list of the major peaks fixed up to that season, to which the 1955 heights are here added[8] in brackets.

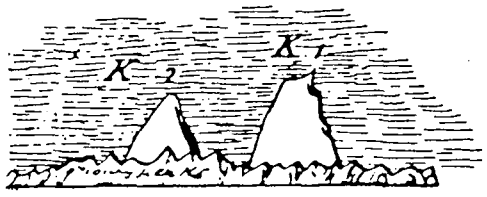
K 2	...	28,287	...	...	(28,250)
Nanga Parbat, or Dayarmur	...	26,629	...	...	(26,660)
K 5, Gasherbrum I	...	26,466	...	...	(26,470)
K 4, „ II	...	26,368	"Hidden Peak"		(26,360)
K 3a, „ III	...	26,103	...	...	(26,090)
K 3, „ IV	...	26,000	...	...	(26,000)
K 1, Masherbrum E	...	25,676	...	...	(25,662)
GK 30 ...	...	25,586			
K 10, Saltoro Kangri	...	25,392	...	...	(25,423)
K 11 ...	...	25,210			
P 12 ...	...	24,698			
K 32 ...	...	24,787			
K 9 ...	...	23,970			
Kun, or Ser ...	...	23,407			
Nun, or Ner ...	...	23,264	...	...	(23,250)
GK 34 ...	...	23,182			

K 2 ; DISCOVERY & NAME

This high western pinnacle of the Karakoram range was first seen and observed by Montgomerie from Haramukh station, about 25 miles north of Srinagar, on 10th

[1] *JASB.* XXVI, 1857, facing p. 266, chart of peaks fixed 1856. [2] DDn. 716 (17), 27-1-57 ; 13-3-57, to SG. [3] Dāmar is the Gilgit name for the peak, not the *massif* name as suggested by Burrard & Hayden (42) ; v. Leitner (23). [4] DDn. 716 (13), to DSG., 27-1-57 *JASB.* XXVI, 1857 (266–74). [5] height first deduced as 27,928 ; *JASB.* XXVI, 1857 (274). [6] local pronunciation preferred to official Skardu. [7] DDn. 716 (298), 30-6-58 ; 717 (53), 30-5-59. [8] DDn. 717 (274) ; 51 (88), TOM. to STS., 1861 ; cf. GBO. Comp. F/12/18 (253, 267) TOM. & G. Scott ; Mason (346-7) ; SG.'s c—854/813, of 13-7-1955, to *Statesman*.

and 11th September 1856 when he made this sketch in the margin of his angle-book[1]. He got one horizontal bearing to K 2 on each day, and two vertical angles on each face between 1 and 2 o'clock on afternoon of 10th [225–6].



J. J. Montgomerie Lt. Engrs.

The Karakoram range is not visible from Hant which he visited a few days later but Brownlow, who carried the principal triangles forward across the Deosai plains during 1857, got both horizontal and vertical angles from Kanuri-Nar, Barwai, and Thalanka on 17th July, and 7th and 26th of August. These observations, combined with those taken from Haramukh the previous year, enabled Montgomerie to fix the position of K 2 with a preliminary height of 28,400 feet [229–30][2].

After further observations by George Shelverton, 1858, and William Johnson 1859 [232–3], Montgomerie reported that the height of 28,287, the mean of several results, will probably not alter much when all the refinements of computations have been applied. The peak may therefore be considered the second highest in the world. ... Several other peaks have been found to be more than 26,000 feet above the sea. The general results show that the ranges to the north of the Indus are very much higher than was ever imagined by former explorers [87, 232, 235].

The surveyors found no "reliable name for this gigantic peak" but, writes Montgomerie, "every endeavour will be made to find a local name if it has one". His little sketch from Haramukh suggests an explanation, for K 1 though 2,600 feet lower is here by far the more prominent, and has the local name of Masherbrum. In 1931 Burrard points out that the great peak had become locally recognized and called "Kaytoo or Kaychoo".

Many names have been proposed. ... Mount Waugh and Mount Albert[3] were considered in 1860. Mount Montgomerie and Mount Godwin Austen were suggested about 1886. Mount Akbar and Mount Babar [emperors of Delhi] were names considered in 1905–6, but none of these names met with general approval in India. So the peak...has continued...as K 2 for 70 years[4].

In 1888, at a meeting of the Royal Geographical Society in London, General Walker suggested that it might be named Mount Godwin Austen, but this was not accepted by the Society, nor by the authorities in India[5]. This name has, however, caught the fancy of many unofficial map-makers and travellers, and is in frequent use. The actual facts of the discovery of the peak, however, make the name particularly inappropriate. The peak was discovered to geographers by Montgomerie and none other[6].

Godwin-Austen had been employed on the Kashmir survey during 1857 and 1858, planetabling in the lower hills of Jammu. He was with his regiment in England during 1859, and it was only after his return in 1860 that he first saw the Karakoram mountains. He made a ¼-inch planetable survey of the Skardo area and "sketched some exceedingly difficult ground, including a portion of the Karakoram mountains upwards of 26,000 feet, ... including some of the largest glaciers in the world". During season 1861 he completed the planetable survey of

[1] GBO. Comp. F-13-63. [2] DDn. 717 (36), 29-5-59 ; Report for 1860, ib. (274) ; 51 (88), TOM. to STS. 1861. [3] after the Prince Consort of Queen Victoria. [4] Burrard (17); cf. *HJ.*, I, 1929 (103–4). [5] *RGS. Progs.*, x, 1888 (616). [6] cf. *The Times*, letter from SG. Pakistān, 22-10-1953.

the glaciers and immediate surroundings of K 2 itself. One of these glaciers appropriately bears his name on the official map [5, 235][1].

In 1936 a conference on the geographical names of the Karakoram region was held in London, at which the Royal Geographical Society and the Surveyor General of India were represented, and this conference endorsed the name K 2[2].

COMPUTATIONS

Observations to the peaks of Nepāl and Sikkim having been taken from principal or secondary stations of the North-East Longitudinal series, their computation had to await that of the principal triangles lying between the terminal base-lines Dehra Dūn and Sonakhoda, and the connections to the sea at Calcutta and Karāchi [21, 66–7][3]. The longitudinal series had not been carried out as a single straightforward enterprise but, as finally accepted, had been observed by no fewer than six surveyors, commencing in 1845 and not closed until Peyton made the final observations in Kumaun in 1851 [16–7][4].

It was only after final adjustment of all discrepancies that positions and heights could be assigned to the stations from which those of the snow peaks were to be deduced. The precision of these adjustments was of the greater importance owing to the shortness of the sides connecting these stations compared with the distance of the peaks, and the acuteness of the apex angles of intersection.

Preliminary computation of his own observations was made by each observer in the normal course during recess months [126–7]. Since, however, most of the peaks had been observed at different times by more than one surveyor, the identification and computation had to be carried out as one operation, and this was effected at Dehra Dūn between 1854 and 1856[5] [91, 128, 343].

Early in 1849 the Chief Computer, Radhanath Sickdhar, had been transferred to Calcutta and took no part in these computations [IV, 462 ; V, 128, 341, 354–5, 372]. Later in the year Logan brought his party to recess at Mussoorie, where he computed his field work which included observations to peaks from three stations [84]. He was assisted by Hennessey, who had proved a valuable computer, and later took charge of a small computing section at Dehra[6] [128].

An essential element of the computation of these heights was the refraction coefficient to be adopted for the long rays—taken in one direction only—through atmospheric conditions that were impossible to determine with any exactness—and the Surveyor General had devoted much time and thought to working out suitable rules and formulæ to obtain the best results. After various experiments and discussions with Radhanath Sickdhar, Renny-Tailyour, and others, he summarised his conclusions in a departmental order of 1852 [63–6]. He writes to Montgomerie in 1855 of the

> uncertainties of terrestial refraction, of the laws affecting which our knowledge is extremely limited. Although we cannot...eliminate this uncertainty altogether from the results of single verticals, we can practically reduce it within very narrow limits by great care in the observations—scrupulous attention to hour of observation—and by multiplying independent results derived from several stations at various distances. In this way by a course of experiments on well-defined peaks of great elevation, observed from many stations at great or small distances, we shall be able to deduce a practical law which, if not universally applicable, will at any rate serve as a safe guide for your observations [82, 84, 88][7].

In actual practice it had not always been possible to confine observations to the hours of minimum refraction. The refraction coefficients applied to the snow peak observations were computed from reciprocal observations in the mountain areas of Sikkim, Garhwāl and Kashmir, and diverse values were applied to the

[1] DDn. 51 (50), 20–4–62 ; v. 1-inch degree sheet 52 A. [2] *GJ.*, XC, Feb. 1938 (128, 136). [3] Adjustment to the spirit-levelling came many years later. [4] Armstrong's final connection of the Hurilaong series was made June, 1852 [13]. [5] as suggested by Burrard, *PP.* 26 (6) ; *Nature*, LXXI. 1904 (42, 82). [6] incl. at times Armstrong, Wm. Beverley, Masters, Clarke. [7] DDn. 592 (152), 11–1–55.

various rays; those used for rays from Jirol H.S., to peak XV varied from ·072655 to ·075272[1]. The subject has been discussed at length by Burrard, de Graaff Hunter, and Gulatee [96][2].

By February 1856 Hennessey had completed computation of

the Hurilāong meridional series. ...—North-East longitudinal series: ... triangles for bases, ... about 399—triangles to Himalayan and sub-Himalayan points, about 600—single deductions, principal latitudes and longitudes, about 450—Himalayan heights, ... vertical angles, 350, besides several others computed for identification and rejected on disagreement of results (about 50 finished).

Projected rough sketch of the principal series...and Himalayan and sub-Himalayan points on a scale of 4 miles to the inch for the purposes of identification[3].

This chart showed the whole length of the longitudinal series, with the Darjeeling work, and all rays to the peaks. The individual observers, having no knowledge of any names, had allotted their own characteristics—Armstrong and Nicolson the small letters a, b, c, etc.—Logan mostly accented letters K′, L′, M′, etc.—Waugh and Lane the greek letters. Hennessey now numbered in a continuous series from the east all those peaks that had worked out successfully, "including—I, Chomalari—IX, Kanchinjunga—XIII, Makalu—XV, Mont Everest—XLII, Dhaulagiri—LVIII, Nanda Devi", etc.

Armstrong's (b), reported as 28,799 feet from a single angle of elevation taken between 2 and 3 p.m. [82], was proved to coincide with Nicolson's (h) and the Darjeeling *gamma*, and was computed out as serial XV from seven principal stations, which gave six vertical angles from which the height of 29,002 was deduced. Though the rays observed by Armstrong and Waugh were rejected[4], they contributed to the identification and to Nicolson's success [84]. Lane's horizontal ray from Dum Dangi was used for computation of position, but was accompanied by no vertical angle. Throughout these computations the procedure was that

in cases where only two intersections to a peak have been obtained, unless two accordant heights have also been observed, it has as a general rule been rejected. The maximum difference allowed to a common side of two triangles formed by three intersections is 200 feet; where the difference has exceeded this the peak has been rejected [82, 221, 234 n.7][5].

Nicolson completed observations in January 1850 [19, 85], and presumably computed preliminary heights at Monghyr where he spent the rains of that year, but the Surveyor General was in no hurry to proclaim them[6]. In December he asked the Chief Computer in Calcutta to revise the form for computing geographical positions of snow peaks at distances over 100 miles and with azimuths up to 45° from north. For the next four years he was discussing refraction coefficients [65] and the datum zero height which had to wait till Tennant completed tidal observations at Karāchi at the end of 1855 [74]. As a final check he wrote for the old records of Charles Crawford and Webb and was delighted to find close coincidence with Crawford's Dhayabang and Webb's Dhaulāgiri [III, 48 n.6 ; V, 81, 92]. For the peaks further west the Chief Computer sent up from Calcutta the "Himalaya Angle-book No. 1 of the Great Arc, which contains a sketch of the snowy peaks taken by Mr. Peyton from Kiderkanta station" [81][7].

On 1st March 1856 Waugh at last felt justified in promulgating a few of the more important heights, which he did in a letter to Thuillier in Calcutta[8];

With my letter 99 of 18th December 1855 I transmitted a geographical memorandum on the identification and revision of height of...Dhaulagiri (originally measured by the late Captain W. S. Webb), at one time supposed to be the highest mountain in the world, though my operations in 1847 proved Kanchinjinga to be much higher [83]. ...

The computations of the positions and elevations of all the principal peaks...from Assam to the Safed Koh...have been provisionally completed. ... Previous to publication, however, it is essential that the computations should be scrupulously revised, and every refinement of

[1] OBO. Comp. B. 3/6; *GTS. Syn.* XXXV (XV—I). [2] Burrard & Hayden (53–62); Hunter (6–7). Gulatee, *TP.*, 4 (6–7); 8 (2–4). [3] DDn. 723 (270), 13-3-55; 673 (1), 2-7-55; (16), 12-11-55; DDn. 32 (9), Report by Hennessey, 23-3-56. [4] OBO. Comp. A-11-67. [5] *GTS. Syn.*, XXXV (XX—I); [6] thinking, possibly, of the scepticism aroused by Webb's results of 1816 [III, 46]. [7] DDn. 665 (157), 18–12–55; 32 (87), with list of Crawford's peaks; 670 (62), 9-1-56. [8] DDn. 665 (182).

correction introduced. ... The revision has proceeded to some extent, and I am now in possession of the final values of the peak designated XV in the list in the office of the Surveyor General. ... We have for some years known that this mountain is higher than any hitherto measured in India, and most probably it is the highest in the whole world.

No official corroboration has been found of the statement that 1852 was the first year that the Surveyor General first knew of the great height of peak XV[1]. As early as 1848 he had reported Armstrong's height (b), and this would have been confirmed by Nicolson's field computations of 1850 [82, 91]. Waugh continues;

I...append an attested statement on the geographical positions and elevations of Dhoulagiri, Mont Everest [94], Kanchinjinga, and Choomalari. ... You are at liberty to make use of these results in anticipation of my forthcoming report on the positions and elevations of all the principal peaks of the Himalaya range.

In justice to my able assistant J. Hennessey, it is proper to acknowledge that I am greatly indebted to him for his cordial co-operation in revising these computations. ...

Choomalari	I	from	2	stations	... height	23,944
Kanchinjinga	IX	,,	9	,,	... ,,	28,156
Mont Everest	XV	,,	7	,,	... ,,	29,002
Dhoulagiri	XLII	,,	8	,,	... ,,	26,826.

Hennessey now proceeded to revise the computations of all the other peaks by applying the same coefficient of refraction that had been used for the Sikkim peaks[2]. Whatever his intentions, he made no change to the heights above reported.

The steps required to complete the final values of height of Himalayan point XV are; ...

(1). The adoption of a constant ratio r/c for each of all the stations[3]...from which XV is observed, as also for each of all stations which fix other heights, conjointly with the foregoing stations, r/c having been adopted for only the Darjeeling branch triangulation.

(2). The computation of subtended angles, comparative difference of height, and heights above sea level, for observations from all the stations included in (1).

In addition, ... it is essential that I should examine the working and results generally[4].

No precaution was overlooked. At the Surveyor General's request the Chief Computer amended his formula for "the correction required to the height of distant mountains to reduce to the ellipsoid when the difference of latitude is great", referring to the 1842 edition of Puissant's *Geodésie*, and Hennessey adjusted the height of Peak XV by 0·2 feet on this account[5].

In March 1858 the Surveyor General issued a complete list of peaks in serial order I to LXXX, with the local names where known, and the observers' distinguishing characteristics [85]. These observers included — Crawford — Webb — Hodgson — Herbert — Waugh — Du Vernet — Renny-Tailyour — Logan — Lane — Armstrong — Peyton — Nicolson[6]. In January 1860 he sent to Calcutta for mapping purposes a complete list of points based on the N.E. Longitudinal series with positions and heights. He was still uncertain of the identity of some of the early peaks, such as Crawford's Gosainthan and Kirkpatrick's Jibjibia [II, 70–2];

It is my intention to draw up a report...to Government in order that permission may be obtained from the Nepal Durbar to my detatching a party into Nepal, as the only accurate way of solving these geographical questions satisfactorily [85][7].

All the peaks from Sikkim to beyond the Indus, with the rays of observation and the triangles on which they are based, are shown on the 32-mile chart of 1857 [121], and also on the 96-mile Index chart of 1870 [pl. 3]. Much interesting information about them will be found in Burrard & Hayden's *Sketch of the Geography and Geology of the Himalaya Mountains and Tibet*, and in Mason's *Abode of Snow*. In his preface to the final professional report on the N.E. Longitudinal series dated 1909, one of the last to be completed, Burrard claims that,

on an average the points on the Himalaya Mountains are correct in latitude to ½ of a second, and in longitude to about half that quantity. The heights are probably true to 10 feet, but they are all too low from the deflection due to mountain attraction. Deflection causes the

[1] Burrard & Hayden (195); *Nature* 1904 (42, 82); Howard-Bury, *Intro.* by Younghusband; *Geod. R.*, L, 1922–5 (246). [2] now known to have been excessive, Hunter, *PP.* 14. [3] r/c = refraction coefficient. [4] DDn. 673 (25), Hennessey to SG., 6–3–56. [5] DDn. 671 (81), SG. to Ch. Compr., 18–7–56; reply, DDn. 662 (237), 11–8–56; TS. 15 (99–101). [6] DDn. 32 (120–3), 22–3–58. [7] DDn. 66 (112), SG. to DSG., 6–1–60.

surface of the geoid to be inclined to that of the mean spheroid, and also to be raised vertically above that of the spheroid. ... We are reluctant to introduce the additional complexity until we possess more certain data[1].

MOUNT EVEREST: HEIGHT

The height of Armstrong's peak (b), 28,799, was derived from the nearer of the two stations, distant 160 and 180 miles, from which it was intersected, and the Surveyor General told Government that he awaited verification "from stations less remote [82]". Such verification did not come till December 1849, when Nicolson got a series of observations from stations between 108 and 119 miles distant. The final height had to await various adjustments and a reliable datum level. The result was taken out for Peak XV by Hennessey's computing section at Dehra Dūn by the end of 1855, and announced by the Surveyor General on 1st March 1856 with the name Mont Everest [91, 94].

Position was obtained by 11 triangles formed by rays from 7 stations—that taken by Lane from Dumdhangi having no vertical angle—leaving the following six stations, from which Nicolson had taken vertical angles [85];

Jarol	giving height 28,992 feet	Ladnia ...	... 28,999 feet
Mirzapur	,, ,, 29,005 ,,	Harpur ...	... 29,026 ,,
Janjapati	,, ,, 29,002 ,,	Menai ...	... 28,990 ,,

giving a mean value of 29,002, which remained the official value till 1954, except for a few years from 1890 when a correction of 8 feet brought by spirit-levelling was temporarily admitted[2]. These stations lay between 240 and 270 feet above sea-level, and at distances averaging 96 miles from the peaks.

Burrard states that the close agreement was effected by slight variation in the coefficient of refraction used, which lay between ·072 and ·075, now known to have been about 15% too large [65 n.7][3]. The vertical angles had all been taken between 2·30–5·30 in the afternoon.

As Waugh repeatedly pointed out, the restriction of observation to distances of over 100 miles destroyed all hope of precision. For any satisfactory determination it was imperative to allow surveyors a very much closer approach. Further observations were taken from Sikkim after 1880, which had the advantage of greater elevation, though still at too great a distance[4]. Combining these observations with those of Nicolson, and using lower coefficients of refraction deduced from Shaw's researches [66], Burrard deduced a new height, 29,141, which he published in 1905 without claiming it to be in any way final. He had no data for adjustment to the geoid, and insufficient grounds for changing the original 29,002[5].

Waugh was fully aware of the obstacles to accuracy—the length of the rays—the uncertainty of refraction—and the indeterminate deflection of the plumbline from mountain attraction [65]. He was already in touch with Archdeacon Pratt on this latter subject [136–7], and it was indeed his great interest in the subject that led to later research by Burrard and others, and to knowledge of the geoidal figure of the earth. As a result of field observations after 1910 sufficient material was collected to allow tentative estimates first of 29,080, and then 29,050. for the height of Mount Everest above the geoid. In 1928, however, de Graaff Hunter advised that any change in the official height should await observations at shorter range, whilst in 1951 Bomford put the case for "no change" from an eminently practical point of view ;

It is premature to make any change ; 29,002 is probably a bit low, but it still *might* be correct, and it is probably better than 29,141. Anyway, there is the general rule that heights

[1] TS. 15 (26); *GTS.* VII & *Syn.*, XXXV (xiv—L); Burrard, 25-11-1909; cf. comments in *TP.* 8. [2] GBO. Comp. B-3/6, 5/11 ; DDn. 665 (182), SG. to DSG., 1-3-56 ; Burrard & Hayden (58) ; GTS. charts, *GE.*, 1890–9. [3] Burrard & Hayden [54–62]. [4] 3 stations 1880–3 ; 2, 1902 ; nearest about 90 m. distarts, elevation 8,507 to 11,929. [5] GBO. Comp., B–3–8 (273–87); *GTS.* ; *PP.* 9, 1905 ; Burrard & Hayden (133–5).

are *names*, and frequent change is intolerable. Whatever the error may be, neighbouring lower peaks are likely to be wrong by a similar amount. ... I think it would be very wrong to change from 29,002 until the Surveyor General of India is able to decide on a height likely to be finally correct to within 10 or 20 feet[1].

From about 1950 the situation was entirely changed by the opening up of Nepāl, and from 1952–4 parties of Indian surveyors were permitted to enter east Nepāl, extending triangulation to stations within 50 miles of Mt. Everest, at heights between 8,000 and 15,000 feet. Further observations taken for gravity and deflection indicate a rise of about 109 feet from the geoid in that region.

Analysis of the results enabled the Surveyor General to promulgate a new official height of 29,028 feet above sea-level at time of minimum depth of snow, and this is considered correct to about ten feet[2]. There are still too many indeterminate factors for an exact figure ever to be obtained.

Waugh's figure of 29,002 was a fortuitous approximation to this latest value, his excess correction for refraction being almost balanced by absence of correction for plumbline deflection. The survey of these colossal peaks was, however, a triumphant achievement, entirely due to his grasp of essentials, and to the determination with which he directed both field and office operations.

MOUNT EVEREST: IDENTITY & NAME

From the very circumstances under which its existence was discovered, that is, by observation from the plains of Bihār, one hundred miles distant, it was impossible for the surveyors to make close enquiries regarding a local name for this king of all the peaks. Waugh had emphasized this difficulty when he pressed for permission for a survey party to enter Nepāl [85, 92]. Though a few of the most conspicuous peaks had names that were known to all the world, the highest of them all was far from conspicuous, having an arc of satellites to conceal it from the south.

Finding no local name, Waugh felt entitled to propose one of his own choosing, and he writes to Thuillier in March 1856 [91–2] ;

I was taught by my respected chief and predecessor, Colonel George Everest, to assign to every geographical object its true local or national appellation. ... But here is a mountain, most probably the highest in the world, without any local name that we can discover, whose native appellation, if it has any, will not very likely be ascertained before we are allowed to penetrate into Nepal, and to approach close to this stupendous snowy mass.

In the meantime, the privilege, as well as the duty, devolves on me to assign to this lofty pinnacle...a name whereby it may be known among geographers, and become a household word. ... In testimony of my affectionate respect for a revered chief—in conformity with what I believe to be the wish of all the members of the scientific department over which I have the honour to preside—and to perpetuate the memory of that illustrious master of accurate geographical research—I have determined to name this noble peak...Mont Everest[3].

He chose this form "Mont" as more appropriate for a single definite peak as opposed to an extended *massif*, but changed to "Mount" a year later. The name Everest was "cordially" accepted by the Secretary of State[4]. Thuillier announced the discovery at a meeting of the Asiatic Society on 6th August[5], and explained the mode by which these snowy and distant peaks had been laid down, ... and showed that the independent results of all the observations to Mt. Everest were most satisfactorily accordant, in fact, ... closer than could have been expected [93], because the mountain, though lofty and massive, is not [seen as] a sharp well-defined peak and was observed from great distances.

This announcement was immediately challenged by Brian Hodgson, formerly political Resident at Kātmāndu, and now residing at Darjeeling [85 n.4][6]. In a letter dated 29th August to the Asiatic Society he claimed that the newly found peak could be none other than Devadhunga, or Bhairathan, both names well known in

[1] *Geod. R.*, I, 1922–5, Hunter (287–99); III, 192–6 (133–5); note by Bomford, 18–12–1951. [2] *SI News* 93, Nov. 1954 ; *TP.* 8, 1954 ; *HJ.*, XIX, 1955–6 (174–5). [3] DDn. 665 (182), SG. to DSG., 1–3–56. [4] SSI., mil., 2–1–57 (24), replying to SG.'s letter of 17–7–56. [5] reported, *Ben. Harkaru*, 28–8–56. [6] reedg. Darjeeling 1844–59.

the ancient literature of Nepāl. Waugh was sceptical, but spent some time investigating this claim which was strongly supported by the Asiatic Society. He writes to Thuillier in the course of private correspondence ;

Of the ten peaks or more which may be Deodhanga, nobody but a qualified surveyor, triangulating from a fixed point of departure into Nepal, could identify Deodhanga and prove it to be the same as Mt. Everest or any other point. Nobody in the plains can point out Deodhanga, nōt even a Gorka, nor from Darjeling or Katmandoo. It is impossible for a human being, however well acquainted with a peak, to recognize it for certain at a great distance under a change of aspect and position. ... The difficulty is well known to us, but not to Hodgson or the Asiatic Society [82, 227]. ...

Mr. Hodgson considers the native name of Mont Everest is Deodhanga or Bairothan. ... These names appear to appertain to some peak near the Kuti Ghat, but as the position of that Ghat is uncertain...there is no point of departure for our investigations. The evidence only shows that there is a peak called Bairaoa or Deodhanga considerably to the east of Khatmandoo, but there are many peaks. ... We have nothing on which to base a verification[1].

Hodgson was persistent and supported his suggestion by rough sketches showing the possible position of Devadhanga, but all so vague as to be the more difficult either to accept or refuse, so in 1857 Waugh summoned a departmental committee to investigate the whole question — Tennant — Hennessey — Montgomerie — Scott — Armstrong ;

Mr. Scott...has spent a quarter of a century in unravelling more intricate geographical problems than this. ...

Mr. Hennessey has been engaged on all the computations for determining the positions and heights of the principal peaks of the Himalaya range, including Mount Everest. ... He also saw Mount Everest when he was engaged on the North-East Longitudinal series.

Mr. Armstrong is one of the gentlemen by whom Mount Everest was observed[2].

The committee could find no evidence in Hodgson's vague accounts of Devadhanga that pointed to any definite peak or mountain, and certainly not to Peak XV, which would not be "visible...from the confines of Nepal...as a great mass", as Hodgson had described the Devadhanga of legend. The name was declared indefinite and unacceptable. Waddell writes later that many hills in Nepāl are known by this name which signifies "God's Seat"[3].

The German brothers Schlagintweit were travelling in India on scientific enquiry between 1855 and 1857, and were asked to help in the search for names of peaks [86 n.2, 144–7]. Hermann took observations from Sikkim and from Kaulia in Nepāl, making detailed notes and sketches. From Sikkim he mistook Makalu for Everest, standing close to the line "high and impressive". From Kaulia he took peak XX for peak XV, and announced that Gaurisankar was the right name [96 n.4].

Even though his errors were clearly demonstrated, the Gaurisankar legend long persisted, and on its revival in 1903 the Surveyor General, Colonel Gore, obtained permission for Captain Wood of the Great Trigonometrical Survey to enter Nepāl and clear the matter beyond dispute. Wood took observations from two stations including Schlagintweit's Kaulia, and

found that Mount Everest and Gaurisankar were different peaks thirty-six miles apart, and that the imposing peak...known to the Survey as peak XX, was the famous Gauri Sankar of the Nepalese. He also discovered that Everest, far from being conspicuous, was almost obscured from view by intervening ranges,

just as had been foretold by the committee of 1857. Wood's report of 1904[4] was hailed by Burrard with an article relating *The Story of a long Controversy* which made a powerful plea for leaving the name Mount Everest to stand as a "monument to honour the founder of the Great Trigonometrical Survey"[5].

Whilst there was no justification whatever for the names Devadhanga or Gaurisankar, there were many champions of the name Cha-mo-lung-ma that was first put forward in 1907, and strongly pressed by the great traveller Sven Hedin in a book published in 1926. In an exhaustive reply Burrard gave a full history of the

[1] SGO. fd. corr., 26-9-56. [2] DDn. 648 (328), DO., 22-4-57. [3] DDn. 718 (440-5), 30-7 & 3-8 & 27-8-1857; *RGS. Progs.*, III, 158; Waddell (347). [4] Wood, I, 1904, with profile sketches; *PP.* 26 (5); Burrard & Hayden (24-5). [5] *Nature* LXXI (42-4), 10-11-1904.

various suggestions, concluding that the Tibetan names applied to the whole mountain mass of which Mount Everest formed one single peak, undistinguished by any local name.

Burrard further protested against the introduction of names for minor peaks that had been concocted during the expedition of 1921, such as 'Lhotse' for South Peak and 'Nuptse' for West Peak. Such names are, however, essential to mountaineers just as names have to be invented by soldiers for tactical use[1].

Burrard's article in *Nature* of 1904, as well as his paper of 1931[2], had been written without full knowledge of all the correspondence between 1848 and 1857. He did not know of Armstrong's unchecked height of 28,799 [82], nor of Nicolson's field computations [91], nor indeed of Radhanath's transfer to Calcutta in 1849 [90]. He probably had not seen the official letter from London of January 1857, accepting the name Mount Everest, with height 29,002 [94 n.3]. Much indeed has been written on the subject.

Herbert Cowie has left a full note on the various phases of this controversy and gives a complete bibliography[3] ;

JRGS., 1857 (xci).
RGS Progs., II, 1857–8, 2 (102–15) ; VII, 1885 (752–3) ; VIII, 1886 (88, 176, 257).
GJ., XII, 1898 (564) ; XXI, 1903 (294–8)[4] ; XXIII, 1904 (356) ; XXV, 1905 (173).
JASB., LVI, 1887–8 (7).
AJ., XII, 1884–6 (438–60) ; XXI, 1902–3 (33–5, 317–20) ; XXII, 1904–5 (56–9).
Petermann's *Mittheilungen*, 34, 1888 (338–41) ; 36, 1890 (251–2) ; 47, 1901 (40–3, 289) ; 48, 1902 (145).
GR Trig. 1873–74 ; appx. iv.
Schlagintweit, II, 1862 (297) ; III, 1863 (193) ; Atlas 1-B.
Tanner, *Mount Everest*, Calcutta, 1890.
Boeck, *Verschlossene Land, Nepal*, Leipzig, 1903 (314).
Waddell, *Among the Himalayas*, 2nd edn. 1900 (345).
Freshfield, *Round Kanchinjunga*, 1903 (199).
Nature, LXXI, 1904 (42, 82).
Burrard & Hayden, 2nd edn., 1933 (20–5, 194–6).
Wood, I, *SI Uncl.*, 2, 1904.

To these must be added others mostly of later dates, inspired first by the earlier climbs, and eventually by the grand success of 29th May 1953.

Sven Hedin, *Mount Everest*, Leipzig, 1926.
Burrard, *PP.*, 12, 1912 ; 26, 1931.
Gulatee, *TP.*, 4, 1950 ; *HJ.*, XVII, 1952 (131–42).
de Graaff Hunter, PP. 14, 1913 ; *RAS ON.*, 3/15, 1953. *GJ.* CXXI, 1955 (21–6).
Mason, *Abode of Snow* (73), 1955.
Gulatee, *TP.*, 8, Dehra Dun, 1954. *The Height of Mount Everest* ; *GJ.* CXXII, 1956 (141–2).

[1] *Statesman*, 21–7–52 ; letter from Tashi Tsering, 17–7–52 ; *PP.* 26, Burrard, 1931. [2] and also Burrard & Hayden (195). [3] SRS. file 77 of 1922. [4] *GJ.*, XXI March 1903, facing p. 296 Freshfield gives telephoto views—from Kaulia, pk. 29,002 only just visible—, and from Sandakphu, clear and massive beyond and flanking Makalu [95].

CHAPTER VIII

RECONNAISSANCE & PREPARATION

Instructions — Approximate Series — Lay-out — Ray-traces — TOWERS: *Bengal — East Coast — Indus Valley — Punjab —* PLATFORMS *& Marks.*

DURING his thirteen years as Surveyor General Everest had worked out detailed rules for his triangulators, constantly providing for new conditions and difficulties, and always striving to maintain the highest precision [IV, vii, 2, 11].

His successor, Waugh, had no wish to introduce changes but, as new officers were appointed to independent charge, new instruments introduced, and new ideas put forward, he had continually to repeat the old instructions, elaborating or modifying where necessary. And then as work extended into fresh ground—forest-clad *tarai*—low and densely wooded hills in Orissa, Assam, and Gujarāt—mountain tracts and peaks of Himālaya—deserts of Rājputāna and Sind—he had to introduce changes here and there, but always with the steadfast purpose of maintaining the high standards he had inherited.

His first task was to carry forward Everest's plan for the North-East Quadrilateral with its grid of two great longitudinal chains connected up by the subordinate meridional series across the Ganges valley. He threw out the important East Coast series that eventually stretched from Calcutta to Madras, and extended the North-East longitudinal eastward into Assam. On the call to extend operations to the north-west [34] he again laid stress on control by two longitudinal chains, the northern hugging the foot of the great mountains towards Peshāwar, the southern continuing the Calcutta series westward from the Great Arc to Karāchi.

He thus discusses the siting of new base-lines ;

> Formerly it was the practice to measure a base of verification at every 300, or about 200, miles apart. ... My predecessor, however, with the boldness peculiar to his character, ventured upon a considerable extension, ... and the confidence he felt in the superiority of his instruments, together with the scrupulous care with which the operations were conducted, fully warranted the innovation. ...
>
> The measurement of a base-line in a satisfactory manner by means of the compensation bars...requires the aid of 9 or 10 experienced observers accustomed to the use of microscopes. These...must be withdrawn from the several series, and assembled at...the base. During their absence on this duty and the time occupied in journeying to and fro, the triangulation...must languish to a greater or less degree. This evil renders the measurement of a base-line a very expensive as well as dilatory operation, and it was chiefly with the objects of avoiding this... that my predecessor was induced to extend the distance between his measured bases[1].

On these grounds Waugh was content to control his triangulation with the addition of four base-lines, Sonakhoda, Chach, Karāchi, and Vizagapatam [19–20, 29, 42–4].

When an officer set out to start a new chain of triangles, his first instructions gave the general line to be followed, possibly a meridian of longitude or parallel of latitude, and a starting point or particular side of existing triangulation, with discretion to change if the old marks could not be found, or if the first side was unfavourable for the new break-out. He was given instructions as to the lay-out of his new series, whether double polygons or long-sided quadrilaterals for important chains—or single, short-sided triangles for subordinate connections. Astronomical azimuths for direction had to be observed at the starting station and at suitable intervals along the line [22–3, 38, 45].

[1] DDn. 452 (227–34), SG. to Mil. Dept., 8–2–45.

The surveyor was warned of any known peculiarities of his principal theodolite and the changes of zero required to mitigate the errors of graduation. Instructions were given as to secondary and minor triangulation for the survey of some great river, or for fixing an important city, or connecting up revenue or other surveys.

Before observations could be made with the "large theodolite", the officer in charge had to make careful reconnaissance of his starting area, generally deputing a senior assistant to carry forward an "approximate series", selecting stations by ray-trace where needed [103–5, 409]. Platforms or towers would be built, trees cleared, and mutual visibility tested, and positions fixed by a light theodolite. A triangulation chart was essential.

Du Vernet was given particular instructions for the North-West Himālaya series [34–5];

Amsot to Banog is the last side of the north-west flank of the Great Arc series, and from that side your principal triangulation will emanate. Both these stations have been marked by platforms of masonry, ... but in the event of one or both...being found injured, or...the marks appearing in any way doubtful, you will...fall back along the Great Arc series until you find a side of a triangle whereof the identity of the station marks is beyond all question. ...

You should be equipped with one of the best 24-inch theodolites available. ... It will be absolutely indispensable in a work of so much importance as the North-West series to take with the 24-inch theodolite 24 angles distributed over 6 changes of zero, and as there are 5 microscopes, we shall thus obtain readings at every 6° of the limb [34, 115].

With the same view of rendering the work first-rate...and preventing undue accumulation of error, ... I would...recommend you to endeavour to establish a series of simple quadrilaterals. ... The platform should be very steady and the instrument well isolated from the tread of the observer. ... The size of your triangles must, of course, conform to the features of the country. ... If a choice be available, sides of 30 miles would be most convenient, ... and if...in the form of quadrilaterals the diagonals will average about 50 miles. ...

If...we consider the convenience of access to the lower hills, the facility of obtaining provisions, their salubrity, ... the absence of snow, ... and the adaptation of the climate to your native establishment, ... it would be better to adopt stations in the lower range, rather than place the northern flank of your series in mountains of very great altitude [36–7]. ...

As mountain attraction deflects the plumb-line, ... angles of elevation will all be erroneous to a greater or less amount, according to the azimuths of the objects observed. The maximum effect will be in a N.E. and S.W. direction, and this deflection will occasion an error of about 90 feet of elevation in 100 miles of distance [92–3, 133–4]. It would appear advisable...that resort should occasionally be had to barometrical observations. ...

Although azimuths of verification will be seriously vitiated by mountain attraction, ... they...therefore be observed at convenient stations one degree of longitude apart[1] [132].

Renny was given the following instructions for the Great Longitudinal series;

Considering the flat character of the hills to the west of Kalianpur, it may...be found no easy matter to establish your first triangles. Should the difficulties prove insuperable, it will devolve on you to consider...some other side of the Great Arc. ... In order that the series may conform as nearly as practicable to the...parallel of Kalianpur, whereby the northern flank will fall near the parallel of Karachi, on reaching the desert a slight bend to the northward may be necessary to avoid the Run of Kuch. ... I would recommend you to take measures for ascertaining...the real character of the desert [39–40]. ...

I would advise you to make your series double throughout by forming a succession of quadrilaterals or polygons, or a combination of both, ... avoiding complicated figures on account of the heavy computations they involve[2] [101].

Amongst the many professional circulars that Waugh issued for the guidance of his officers was one entitled *Practical Instructions for conducting Great Trigonometrical Survey Operations*, reprinted Dehra Dūn, 1865.

This was based on instructions originally prepared for Thorold Hill when he started the Coast Series in 1845 [22–3], and was distributed to field parties in March 1856[3]. Other professional papers are collected in two volumes of "Waugh's Manuscripts", the second being entitled "Papers Mathematical & Miscellaneous".

[1] DDn. 492 (58–71), SG. to Du Vernet, 12–6–47. [2] DDn. 493 (66), SG. to Renny, 16–9–48; amplified for Strange, DDn. 616 (35), 8–9–49; (72), 30–4–50. [3] GBO. Comp G-6/9. & M. 9/5 (120–350); GBO Lib. Hm 3; Waugh Mss. II (viii); *Roorkee Papers*, IV; CLIXXX (303–16; 413–22); DDn. 715 (151), 24–3–56.

An approximate series was the line of triangles laid out in advance of the main work and so prepared that the final angles could be observed without any delay or check. This involved the selection of stations to form suitable triangles grouped either in single or compound figures, and the erection of suitable platforms or towers with both upper and lower markstones. The triangles had to conform to departmental rules for symmetry, and to any special instructions for the series. Provision was to be made for sound junction with other series—lines of sight cleared and tested for visibility—and at least two angles of every triangle observed with a light theodolite, and so recorded that the lay-out might be plotted on the chart for approval by the Surveyor General and guidance of the observer.

In some cases, especially in the more difficult ground of the Ganges valley, the *tarai*, the East Coast, or Assam, the officer in charge himself devoted several months, and possibly a whole season, to this approximate series. Sites for stations might have to be found by ray-traces, leading to tiresome negotiations for the felling of trees [477–8]. Heights of towers and platforms were to be determined and arrangements made for collection of building material and labour, and close supervision of construction.

As a general rule—after the first start—the officer in charge handed over responsibility for this advance work to his senior assistant, whilst he himself went back to observe the final angles [38, 57, 222, 409].

After Rivers had twice failed to complete his programme to Gujarāt through the unhealthy coastal belt [55] the Surveyor General suggested that he should

> leave all heavy baggage, and even the 18-inch theodolite behind, and with the whole means at your disposal...carry an approximate series as rapidly as possible across the tract, ... stopping at each place not longer than is necessary to choose the station, take the approximate angles, and prepare platforms. ... You are not likely to be delayed more than 2 or 3 days at each place, whereas, according to your present plan of combining the measurement of final angles with the selection of stations, a long detention at each place is unavoidable. ...
>
> If the unhealthy tract is a very broad one, the selection of the approximate series may perhaps occupy the whole season, and it is...advisable to carry the approximate triangulation right across the dangerous tract into a healthy country on the other side before attempting final angles. ... The approximate series should be pushed on at least 5 or 6 triangles in advance of the final work, ... but, if the country is very difficult, it is better to apply the whole power... to the single object of selecting the series[1].

William Rossenrode, like his father before him [III, 499], was specially successful on this important work, on one series after another—Maluncha—Great Longitudinal—Great Indus—East Coast—and the Eastern Frontier [31]. Of his work on the Great Longitudinal series through the Aravalli Hills, Strange writes ;

> Every station of last season's approximate series...has been visited by Mr. Rossenrode in order to have the platforms built and secondary marks set up. ... Three stations of the old approximate series...have been altered, the first two by Mr. Rossenrode, the latter by Mr. Pierce. ... The three stations forming the triangle of connection between the Khanpisura and the Great Longitudinal series...have been examined by Mr. Rossenrode, the positions of their respective marks...being accurately measured and recorded. ...
>
> The approximate series has been continued westward by Mr. Rossenrode to...about 30 miles beyond Mount Aboo being a distance of about 150 miles, and consisting of two single polygons, one double polygon, and one quadrilateral. ... 24 platforms have been constructed in principal stations, the pillar for the reception of the instrument and its isolating anulus being of substantial masonry. They have all been built under the superintendence of Mr. Rossenrode except...[two] which were erected under my own direction[2] [38].

To Strange's call for extra help the Surveyor General was not sympathetic ;

> The whole ground...has...been traversed by Mr. Rossenrode, whereby the most formidable part of your work has already been achieved. A great part of my early labours...were expended in station selecting, in which I had no such valuable assistance as Mr. Rossenrode renders you. This was the only part of the work that ever gave me the least anxiety[3].

[1] DDn. 325 (417–39), 15–5–46. [2] DDn. 594 (63), Strange to SG., 1–5–50. [3] DDn. 616 (106), 7–10–50.

No one who has not been arrested in the midst of fine observing weather by the want of selected stations in advance can really appreciate the immense effect produced on the out-turn of work by the operations of a skilful advanced party. ... In no case has it been carried out with such complete success as by Mr. Rossenrode[1].

When observation of the final angles could not be taken up till after the lapse of several months, or even one or more field seasons, a great deal of the preliminary work would have to be re-done. Towers might collapse or be washed away, either through faulty construction or heavy rainfall. Jungle would spring up along the line of sight. Sometimes the observing officer would dislike the original lay-out, or have to adjust it to the work of an adjacent series. The re-siting of one or more stations would then involve the construction of new towers or platforms and the clearing of several new lines.

Rossenrode's first lay-out of the Great Indus series along the west, or right, bank of the Indus was very much of an experiment, and Tennant found many reasons for departing from it. Though safe enough from interference from tribes of the Baluchistān border whilst Rossenrode's small party was in the field, Tennant found the risks too great for his more deliberate operations, nor did he like the alignment across the riverain plains to the north. After the interval of more than three full seasons, when observations were resumed by Keelan, many of Rossenrode's towers had collapsed, and very few of his stations were incorporated in the final line [45–6, 110].

From the Sind deserts Rossenrode was transferred to the East Coast jungles where progress had been repeatedly held up [27–8]. After two seasons the approximate series was so far ahead that Waugh had no qualms about moving him away to Assam where a man of his experience and energy was sorely needed [31]. He writes to Nicolson who had been struggling with no experienced assistant;

Two polygons should at least be laid out in advance in the first instance, and the advanced party should be so well equipped as to be able fully to maintain this interval, or rather to progress more rapidly than the final work. ... The Great Longitudinal series under Captains Renny-Tailyour and Strange has progressed most favourably, the approximate triangulation being sometimes more than 100 miles in advance, and the final work having obtained a progress of about 50 great triangles per season.

In no case is it admissible to take final angles at stations not definitively established, and which require to be afterwards rejected for others. This has never occurred in any well regulated series, and ought not to occur under any circumstances whatever. If the approximate work is carefully laid out, kept sufficiently advanced, and nothing assumed for granted, there can be no occasion to reject any final stations, for this evil arises invariably from a bungling, unsystematic mode of procedure [26, 61][2].

In a later departmental order the Surveyor General concludes that the lay-out shall be absolutely the best the country admits of, so that no other person visiting the same ground could improve it. Selecting stations is one of the most important and arduous operations of the Department. ... It requires great experience, energy, and sound judgement. ...

In the event of any question, ... the case should be submitted to the Surveyor General with a chart showing the improvement proposed, with an explanation of all collateral circumstances. ... The relative symmetry of two series can be judged from the plans, and the Surveyor General will form his opinion thereon [121, 127][3].

LAY-OUT

The gridiron lay-out adopted by Everest consisted generally of an outer frame of two extreme meridional and two longitudinal series closing at each junction on a measured base-line. These main outer chains were executed with special care, and as a rule comprised a succession of polygons or quadrilaterals. When diverting the Maluncha series to work on the North-East Longitudinal, Waugh writes to Reginald Walker;

[1] DDn. 709 (14), SG. to Strange, 29-7-53. [2] DDn. 591 (260), SG. to Nicolson, 1-10-52. [3] DDn. 455 (204), DO., 22-2-54.

The most important parts of the great triangulation of Bengal are those which furnish the basis and verificatory connection of the meridional series, viz., the two great longitudinal chains...on the north and south, and the Great Arc and the Calcutta Meridional series on the west and east. These being immediately connected with the base-lines already measured, and hereafter to be measured, verify all intermediate operations.

He regretted that he had no better instrument for the longitudinal series[1].

The interior of this frame was filled by a number of subordinate meridional chains at a general interval of one degree. Where these ran through flat country it was found economical in line-clearing and tower-building to run them as simple chains of single, well-shaped, short-sided triangles. By this straightforward system the subsequent computations and distribution of errors was greatly simplified; with a continuous network straggling in all directions, and a multitude of redundant cross-rays nothing but confusion resulted. Such had been Everest's criticism of Shortrede's triangulation in the Deccan [IV, 72], and such also was Renny's criticisim of the lay-out of the Karara series in 1844 [IV, 463, 466].

The triangulation is formed in very complicated figures which must require more time to compute than is compensated by the additional accuracy thereby intended. Judging from the work commenced in the plains a double series appears to be contemplated instead of a succession of simple polygons, and the sides of the triangles in the plains are also longer than sanctioned by experience. The computation of...the figure embracing the hill stations is not yet completed; this figure might...with advantage be simplified by treating some of the stations as secondary[2].

The Surveyor General made similar criticism of Armstrong's first lay-out of the Hurilaong Series four years later;

It is composed of a complicated mass of triangles of all kinds, without any continuous series of symmetrical ones. The observations in the field will be very tedious, and the computations cannot be commenced until each connecting part is concluded. Even then, on account of the multiplicity of equations of condition the reductions will be laborious and delay your office work. It is therefore expedient as a general rule to avoid such complicated figures. I prefer simple polygons or...quadrilaterals[3].

He was not happy about the Bombay triangulation, and describes the Bengal lay-out to Rivers, explaining that the object was

to furnish fixed points at distances sufficiently proximate to prevent accumulation of error in the detail surveys. ... A limited number of such points only are necessary, and as their determination is expensive and dilatory, it is inconsistent with true economy to introduce principal triangulation where secondary operations will serve the purpose. ...

In contradiction to the unity of design upon which this system is based, the operations on the Bombay side have always exhibited a tendency to diverge into a network...dispersed in all directions, and arranging itself round Poonah as a focus. ...

There are many other evils inseparable from a confused mass of triangulation. The usual checks...are postponed indefinitely, and when applied it is difficult to disperse the errors upon any satisfactory principle. ... All these evils are the result of not distinguishing between principal and secondary triangulation. The former should be concentrated upon distinct lines of limited breadth...with...scrupulous...attention to exactness.

He thought the Bombay triangles generally too large;

There is no doubt that very large triangles require a very long time for observation. ... Signals at 50 miles distance, for instance, are frequently invisible when there is no difficulty whatever in observing objects at 25 miles, and four triangles of 25 mile sides may generally be finished in less time than two triangles of 50 mile sides [104]. ...

I think 20 miles the most eligible average length of side in a hilly tract, and in a level country about 11 miles. If you could reduce your future triangulation to these dimensions ...you will find it an easy matter at any season to finish the final angles at a station in two days. ... It is to be understood that an approximate series has previously been selected, the platforms built, and the jungle cleared...in the direction of the rays[4] [29, 46, 111].

Whilst it was generally desirable that the chain of triangulation should be as straight as possible, with one flank following a particular meridian or parallel, this was "not a primary object". Symmetry of figures was of far greater importance—no angle less than 30° [IV, 76; V, 102].

[1] DDn. 514 (203), 29-1-46. [2] DDn. 454 (54-6), Renny to SG., 22-2-44. [3] DDn. 498 (184), 16-12-48. [4] DDn. 325 (417-39), SG. to Rivers, 15-5-46.

Stations...should generally be on the highest points, but as these are sometimes inaccessible it may be necessary to adopt a lower point. Above all things it is desirable that the view should be unobstructed on all sides. ... When a lower point is selected...care must be taken that on neither side is the ray obstructed from any higher points which may eventually, either in your own series or in one...to the east or west, ... form...a principal station [61].

The selection of stations being one of the most important parts in a geodetical series, and very various in respect to the difficulties which it presents, ... the entire responsibility of their elegibility rests with the person who conducts the series[1].

Unfortunate instances of insufficient reconnaissance having occurred in other parties [26, 61], the Surveyor General issued two long circulars dealing with all aspects of the field work of a triangulation party. He pointed out the dangers of local attraction and of lateral refraction affecting grazing rays ;

In order that the observed azimuth may be as free as possible from those errors which are caused by local attraction, it is desirable that no great mass of high mountains should stand either east or west of the station of observation, nor be so situated...that the portion of resolved attraction in the direction of the parallel should amount to a sensible quantity.

In choosing stations it is proper to avoid intermediate obstacles situated on or close to the ray, because the ray will certainly be deflected by the vapours which rise from the sloping ground, whereby the observations...will be more or less affected by lateral refraction.

Regarding the shape of triangles he laid down that

triangles selected should be symmetrical, that is, as nearly equilateral as possible, ... but... the rule in practice is to admit of no angle under 30° or above 90°. This rule applies to all triangles which compose a series, ... but in the case of secondary triangles which do not form part of a long series wider limits are admissible [IV, 76 ; V, 101]. ...

In the case of a quadrilateral, ... the best condition...is when...no angle will be much above 90° and much less than 45°. Quadrilaterals are inadmissible...where towers are required to surmount the earth's curvature. In all such cases the hexagon is the proper figure for triangulations of the first order, and single triangles for those of the 2nd and lower orders.

A series should consist of triangles as large as the features of the country admit of. ... The probability of accumulation [of errors] will be least when triangles are large. In hilly countries 20 to 30 miles is a convenient distance for principal stations, and such distances can usually be observed by means of heliotropes and Argand lamps. Where hills are...table-topped...it may be requisite to shorten the sides to less than 20 miles. ... An open country with detached peaks may frequently afford distances of 30 to 40 miles. In a level country such as Bengal, ten-mile sides are the most favourable, and the limit...8 to 15 miles[2].

He was shocked to find that Armstrong had included an angle of less than the regulation 30° in his break-out for the Jogi-Tila Series [52] ;

It is not without considerable reluctance that I contemplate the admission of an angle of 27° under any circumstances. Laxity in matters of symmetry is an intolerable evil, and the selection as it now stands can only be condemned as unskilful and injudicious. If the tower at Gour Station had not been built I should have at once rejected the point[3].

In a letter written to Haig shortly before his retirement, Waugh gives his views on the extension of the Khānpisura principal series towards Mangalore ;

The Mangalore series should consist of well-conditioned polygons. In former days, when the Khanpisura series was carried on, a mixed system was admitted, polygons and quadrilaterals being introduced where convenient. ... As a chain cannot be stronger than its weakest link ; if a single triangle be admitted into a double series, it must weaken the series at that point. This...does not preclude the introduction of polygons and quadrilaterals to strengthen a part...that local circumstances render weak. ...

A flat country with towers, and grazing rays over table-topped hills, are unfavourable. Rays crossing large rivers, swamps and arms of the sea, are also unfavourable, as are likewise sandy wastes, and tracts like the Runn. Such unfavourable spaces are sometimes unavoidable. It clearly would be no violation of principle to traverse such tracts with a double series, and favourable parts with single series. ... The chief advantage of a double series is not so much superior accuracy, ... but the check on the work at each stage of its progress, and the means it affords of detecting an error. ... All important series are now made double throughout, where the nature of the country admits of it without enhancing the cost too much[4].

[1] DDn. 600 (194) SG. to Coast Series, 1-9-45. *Roorkee Papers*, CLIX (309). [2] DDn 601 (1) ; 1863 & 600 (45) ; DO , 22-2-54. [3] DDn 723 (54), SG. to Walker, 8-3-54 ; smallest angle in final lay-out, 30° 3′. [4] DDn. 709 (426), 20-11-60.

Everest's system of ray-trace traverse was still the surest way of laying down triangles across flat country where visiblity was obstructed by buildings and trees. A perambulator traverse was run on a suitable bearing from the initial station till a site was found suitable for the second station. The mutual bearing between the two stations was then computed and located on the ground by offset from the measured line. Everest had adapted this system for the survey of detail along the line between two known stations [IV, 80–1]. An example of such valuable mapping material is found in a "Route Survey made for the purpose of selecting the principal stations of the Karara Series, season 1844/45"[1] [119, 184, 314 n.5].

Armstrong preferred minor triangles to the quicker perambulator traverse ;

In 1835–36, when the Ranghir Series emerged into the plains and ray-clearing was quite a novel undertaking, the projection was made...from route survey if the blue light burned at the station to be cut was not visible when elevated some 30 or 40 feet above the pillar. The distances...were seldom short of 17 miles. ... By route survey the deviation from the correct line was...about two or three minutes...and therefore...I invariably had a scaffold about midway to observe the deviation right or left, and then corrected the alignment.

In the Karara series last year...the data obtained by perambulator work could not be depended upon within two or three minutes, and sometimes more. ... This season the data were drawn from minor triangulation, and, therefore, free from all objections relating to inequalities of surface. ... With such data the alignment must necessarily come correct at least within a minute of the true line, and...will not give a deviation of more than 18 feet at the point of connection. ...

Minor triangulation...is the most correct, the most valuable. It has a fourfold advantage over the other plan. It gives you a double line of stations by which every village within a mile of the flanks is laid down. ... It is executed in nearly as much time as the route survey, and it gives a correct data for clearing rays[2].

In 1851, John Rossenrode was specially transferred to the Bombay party to help Rivers in laying out the Abu series through the Gujarāt plains [57]. The Surveyor General had pointed out that

the general conduct of the work in a level country requires even greater attention to division of labour and systematic arrangement than in a hilly tract. The approximate series must be laid out completely. Several of the towers must be finished near the commencement of the series, and the others must be in rapid progress, ... whilst the ray-clearing also must be in the same state of forwardness before the final observations should be commenced. ...

The best plan...is for the officer in charge to choose all the stations himself, assisted at starting by one of his subordinates, leaving one assistant to built towers and another to clear up the rays, data for which...will be supplied from the ray-trace surveys. ...

A ray-trace of 10 to 14 miles may be traced, and site for a tower chosen, in one day but, ... with other...matters to be attended to, ... the time occupied in selecting a station may be estimated at 2 or 3 days, so that 10 or 15 single triangles may be laid out in a month[3].

Rivers could make little from his ray-traces,

the country being occasionally cut up with nullas, or from the angles not having been observed with sufficient care. The lines first cut have invariably required to be attended to, causing great time and expense and double the injury to the trees[4]. ...

The lines...from the ray-trace surveys were far from true, none indeed of...have been at all satisfactory. I despatched Mr. Da Costa to resurvey one of the lines and took another by myself, and having cleared the trees by the line obtained from the latter, I at length completed those final angles. ... Here also the line...that had been cut differed considerably from the true line. ...

I closed the season's work...on the 19th April. The amount of work has not been as much as the opening of the season promised, as I could easily have completed the three hexagons but for the unsatisfactory result of the ray-traces, generally entailing a second survey, and cutting as well as double the injury to the trees[5] [57].

On the Orissa Coast Clarkson found that

the Hidglee District is so intersected with rivers, deep muddy streams and canals, and moreover abounds with swamp and miry ground, ... that it has been found impossible to use a

[1] ray trace Karara Series, MRIO. 33 (37) ; *IO Cal.* (42) ; cf. DDn. 499 (75–6), SG. instns. to Logan, 24–7–45. [2] DDn. 494 (50–3), Armstrong to Garforth, 13–6–46. [3] DDn. 493 (304), SG. to Rivers, 27–5–50. [4] DDn. 518 (475), Rivers to SG., 3–3–51. [5] DDn. 513 (480), Report 1850–1, 1–5–51.

perambulator. ... On this account, as well as the difficulty in moving over the creeks which come under the influence of the tides, the system of ray-tracing was laid aside [25][1].

For work through the Gorakhpur *tarai* the Surveyor General advised Logan "to carry a route survey in advance to explore the intended site, so that if any mound or high ground lies near the required spot it may be taken advantage of, and if any marsh or low ground exists it may be avoided". He advised him to run compass traverses along forest tracks;

You will be able to select any point to less than half a mile of its true position, and you can then cut up a narrow ray, find the error, and then lay off the true ray. This...will not occupy more time, or cost more money, than scaffolding. ... If the country is dead level, it would suffice to lay off the angles you want and cut up the rays, placing the tower at the point of junction. But...you might fall into tanks, marshes, or rivulets, for even in a tarai there are some spots better than others for sites of towers.

If there be no path, ... then...cut a narrow straight line in the required direction, and after proceeding the distance required you may be able to select a spot either on the line, or an exploration to the right or left will point out the most eligible spot.

He suggested that the surveyor might often find it useful to raise his instrument or a heliotrope on a tree stump or low scaffold at some intermediate point [198][2].

On the Maluncha Series Walker found subtense measurement to a bamboo rod gave better results than perambulator measurement, owing to "the very undulating nature of the country, ... intersected by numerous jheels, nullahs, and rivers" [14][3].

In 1850 the Surveyor General issued a note of "Instructions for selecting Great Trigonometrical Stations in a level country, and Rules for clearing the Rays"[4].

The great triangles should always be designed beforehand on a chart, and stations can generally be selected within a mile of the proposed spot. ... Eleven mile sides are best suited to a country perfectly flat, and the extreme limits of ten miles on the one hand and 13 on the other should not be departed from unless large mounds are available. ... Sides of 22 miles and upwards have been taken with blue lights but the observations are far from satisfactory. The delay is enormous, and the anxiety heart-breaking [101].

The large size of his triangles had been the main cause of Everest's troubles when carrying the Great Arc across the Jumna valley [IV, 26–36]. Waugh continues;

When the accuracy of the ray-trace is doubtful, either a minor series must be carried on to get a better determination, or the ray deduced from the route may be approximately laid out. For this purpose flags must be planted in the line by means of a telescope of the small theodolite, taking care merely to lop off such branches as impede vision, and never to cut down any tree unless its trunk stands in the line. The ray having thus been carried approximately from one tower site to the other the error will become known, and the flags may shifted in proportion to their distances. ...

Flag staves for ray-traces are usually made of stout straight bamboos, 30 to 40 feet high, planted perfectly perpendicular, and supported by 4 stay ropes. ...

Formerly it was the practice...to use scaffolds from 50 to 80 feet high, with a central isolated post for the theodolite, and blue lights were burned on masts 100 to 130 feet high at the opposite ends of the ray. ... To raise scaffolds and masts to so great a height in the jungles requires much ingenuity and enterprise, while the taking of observations on a dark night from a rickety framework of bamboos 80 feet high was no small trial of a man's nerves.

When working through the *tarai* forests the surveyor should decide on the bearing most suitable for his new station, and then open a very narrow gap through the undergrowth and forest. ... He will carry an alignment of flags placed at short intervals apart through the forest until he has attained the proposed distance as indicated by perambulator, after which the surveyor will make a reconnaissance round the spot to ascertain the best site.

If no better ground presents itself, the approximate ray will stand good, and the gap only requires to be enlarged. ... A similar ray must be carried up from the other fixed station... and the meeting of the two lines will indicate...where the tower ought to be built. ...

If...favourable ground is discovered apart from the first approximate line, and in such a position as will not destroy the symmetry of the triangles, then from the spot selected there must be cut a narrow gap through the forest...until it intersects the first...line. The angle may then be observed at the point of junction, and the two distances being measured by perambulators...the angle may be computed which the true ray makes with the approximate.

[1] DDn. 507 (97), 30–8–50. [2] DDn. 499 (171–7), 19–9–46. [3] DDn. 493 (23), Lane to SG., 1–10–47.
[4] DDn. 598 (56) Aug. 1850.

In a dense forest 20 woodcutters can cut a narrow gap for alignment 11 or 12 miles long in 3 days, ... but to clear a final ray of all obstructions will require 40 or 50 woodcutters 3 to 7 days, according to the size of the trees. ... Trees of 10 feet diameter occupy several days to fell and a still longer time to chop down the debris and remove it out of the way.

TOWERS : BENGAL

To bring the Great Arc across the plains from Delhi to the Siwāliks, Everest had built fourteen masonry towers about fifty feet high, which are still standing [IV, 82–3 ; pl. 5]. Some of them were revisited in 1866 [IV, 41 n.3 ; V, 150] ;

The masonry of the tower [Godhna, IV, pl. 4] was as good as, or better than, when it was built, but most of the timber was eaten away or destroyed. These towers...were built up pucka, very strong and massive, and generally in three stories, and have...lasted uncommonly well. It is but natural that all unprotected timber should have rotted away. ... The whole of the old wooden platforms at the top...were...almost entirely destroyed by weather and insects. The roof, ... consisting of a lime-flooring placed on small rafters supported by two massive stone beams on which the pillar for the instrument rests, appeared to be in good order[1].

Cheaper towers had to be used elsewhere, the essentials being—command of clear view to other stations—solid support for the instrument, isolated from the observer's platform—facility for centering the instrument precisely over one mark at the top of the tower and a second at ground level. The lower mark was cut into solid rock or on a large stone firmly embedded.

Each tower had to be sited to conform to a symmetrical lay-out of triangles and, so far as possible, clear of danger from flood and erosion. Height was calculated to allow for curvature of the earth and command over buildings and trees.

Construction had to be sound enough to last through the two or more monsoon seasons that might elapse before final observations were completed. As there was danger that towers higher than thirty or forty feet might settle out of the vertical, it was considered unwise to take observations within three or four months of construction. It was accepted, however, that when a tower eventually disintegrated the debris would form ample protection to the lower markstone, and provide a suitable point for future connection and identification [108].

Except in the hills and uplands of central India, there was hardly any area where towers were not found necessary. Waugh's surveyors had to devote much time and thought to their design and construction on their many lines that crossed the Ganges valley—skirted the foothills of Kumaun and Nepāl—and traversed the Brahmaputra into Assam. From Calcutta southwards the East Coast series lay through the heart-breaking swamps and plains of Orissa for more than two hundred miles with hardly a hillock to help. There was no escape from tower-building when move was made to the Punjab, Sind, and the Indus valley[2].

In his instructions for the Karara series shortly after he became Surveyor General, Waugh describes the type of tower he favoured ;

The tower is constructed of unburned bricks with the exception of the central core or pier which is of masonry, isolated from the external portion...so as to furnish an independent support for the instrument. The platform is from 16 to 18 feet in diameter, and the dimensions at the base are increased in proportion to the height. ...

The ascent is...by a circular flight of steps 4 ft. broad, each step having a tread of 8 inches to a rise of 6 inches. These must be built at the same time with the tower and connected therewith, ... otherwise the staircase will be liable to separate. ...

The height required for the tower is best determined by observation, but...may be deduced from the curvature of the earth's surface[3], ... reduced by the altitude, if any, of the site above the general level, and increased by the height of any intervening obstacles. ... The line of vision...should pass about 5 or 6 feet above the ground in the centre of the ray. ...

The central pier of masonry...should have a diameter at base in proportion to the height, ... and the diameter at top...limited to the dimensions of the stand [of the instrument]. ...

[1] from Trotter, 27–9–66 ; *GR Trig.* 1865–6. [2] *GTS.* VII, Intro. (12–5). [3] ht. in ft. = 2/3 (d)/2. where d = ½ distance in miles.

The depth of foundation is necessarily dependent on...height of the tower and the nature of the soil. ... For towers of 20 to 25 feet a footing of two feet is usual for the central pier. The mud tower, having a broad base, seldom requires more than 6 inches or one foot. ... In lands...subject to inundation...in the rainy season, it will be advisable to construct the foundations and plinth of burned brick. ... In the event of water insinuating itself between the masonry pillar and the mud tower, the latter would inevitably burst, and...it is usual to cover the whole terreplein of the tower with terrace plaister[1].

For raising the large theodolites Waugh recommended straight ramps at least six feet wide, constructed of stone and timber ;

The strength of the ramp should always be first tested by making 16 or 20 men march up and down it. ... In case of a storm the instrument could be boxed and taken down as rapidly as if it were not elevated on a tower[2].

Towers that were to be revisited after the rains required

a strong thatch over the tower and upon the stairs, together with mats...upon the walls...[as] protection against the direct effects of rain. ... Two men should be left in charge of each tower to protect the chappers from mischievous violation, and repair them if necessary. One of these men ought to visit once a month the headquarters of the party for...receiving pay [and] reporting the state of the towers[3].

Further instructions followed in a circular letter of 1850 ;

Square towers have within the last few years been introduced. ... When the tower is square the stair...enables the boxes of the large theodolite to be carried up on the bamboo poles instead of their having to be removed from the box when taken up a circular one. ...

It is not essential to cover the upper surface of the tower and pillar with lime plaister...as it always cracks. A much better plan is to cover the whole of the upper surface of the pillar and tower with loose earth to the depth of two feet in the centre, which fills up the cracks, and at the same time protects the top of the pillar and the markstone. ...

The isolated pillars...are liable to deflect very considerably from the perpendicular, whereby the...upper mark cannot be relied on [19, 42]. ... If some of the observations are taken before, and some after, settlement, ... very injurious effects may be anticipated.

We may now sum up...regarding the several kinds of towers which have been used. ...

1st. Isolated pillars and scaffodls are failures owing to their oscillating with the wind. ...

2nd. Hollow towers with pillars resting on cross beams and a boarded platform, similar to the plan given in Col. Everest's work, have succeeded well[4] [IV, 82]. The mark being on the ground cannot be deflected and is easily referred to. Altho' the isolation of the instrument is not theoretically perfect...no evil results have been observed. ...

The Barrackpore base-line towers are 75 feet high, and the towers of the Great Arc were chiefly 50 and 60 feet. Col. Everest used stone cross beams, and the total expenses of his towers were 2,000 and 3,000 Rs. each [IV, 94, 83]. The towers of the Calcutta Meridional series cost about 300 Rs. on an average, but wooden beams were used [108].

To avoid the risk...of craning up the instrument, the solid tower was introduced by Captain Renny-Tailyour in 1835–6. These were originally built of mud...and cost about Rs. 5 per foot of height. ... Afterwards internal isolated pillars were added, the expense rising to 6 or 7 Rs. per foot vertical. After a short trial it was found necessary to add buttresses. These towers were...very convenient. ... The instrument could be put up...the moment it arrived. ...

The stability of the upper marks cannot be trusted, consequently where solid towers have been built, external marks should be added as a test of deflection, but for new towers the means should be given for referring directly to the under-mark by a perforated pillar and vault. This vault must be closed on leaving the station [41, 109][5].

To provide against the vibration of a high central masonry pillar, Waugh advocated all-round support for part of its height by a mound of earth and brushwood, the observer working from a wooden scaffold [108]. To provide against destruction of the upper markstone, he recommended the insertion of an intermediate mark some six feet below the top of the pillar, and the removal of the lower part of the ramp or steps after observation[6]. He stressed the importance of

inserting the markstones in due vertical correspondence. ... Common workmen will make an error of a foot between the upper and lower mark. I always entrust this duty to a Sub-Assistant or to a carpenter whom I had trained to habits of accuracy.

[1] DDn. 598 (32), SG. to Shortrede, 19–12–43. [2] DDn. 499 (168–70), SG, to R. J. Walker, 29–8–46. [3] *chappar* = sloping thatch ; DDn. 498 (8), DO., 18–4–44. [4] *Mem'dl. Arc*, II, pl. 25. [5] DDn. 598 (36–44), CL. June 1850. [6] DDn. 496 (228), SG. to Logan, 6–11–48.

Captain Renny...caused a markstone to be buried in the foundation and four markstones to be buried in the ground exterior to the intended structure, so that cross threads stretched between the latter corresponded with the centre mark. The upper mark was afterwards placed by himself or assistants by reference to the exterior marks, using plumblines. ...

On the Ranghir series I had a hollow tube in the pillar which admitted of direct reference to the mark at the base; side arches [were] also furnished to admit light and clean the mark[1].

In 1870 General Walker reviewed the developments of tower design;

In course of time it was ascertained that a tower with a solid central pillar was not...perfect. ... The pillar was found to be liable to settle to one side. ... The settlement commonly occurred during the monsoon...when the ground round the base of a tower is generally flooded with water. ... For some time the evil was not suspected because...the structures were fashioned rudely and irregularly by common...artificers, and there was always a doubt whether a deviation...was due to actual deflection or to the crooked eyes of the builders.

It was guarded against...by making the pillars hollow instead of solid, with a vertical shaft running through them down which the markstone—now placed at the ground level instead of on the top of the pillar— ... could be seen from above and plumbed over. A passage through the base of the tower gives access and light to the markstone. This arrangement was introduced by Colonel Waugh about the year 1852, and has been attended with excellent results.

In portions of lower Bengal, which are always damp and humid, and liable to heavy falls of rain during the working season [463 n.3], it has occasionally been found necessary revert to Colonel Everest's form of a hollow rectangular tower built of masonry. ...

In other parts of Bengal bamboos have been plentiful, whilst burnt bricks have been difficult to procure. ... Bricks have, therefore, only been obtained in sufficient quantities for...the pillar, and the surrounding platform has been fabricated of bamboos and matting.

In the drier climates of the Punjab and the North-West Provinces the platform is usually built of sun-dried bricks moulded on the spot, and occasionally clods of earth, faggots of wood, or any other materials which were serviceable and handy have been employed.

Various types of towers had been used on the North-East Quadrilateral, mostly with unskilled labour and the strictest economy;

On the Budhon Series solid earthen towers were erected, each with a hollow core of masonry in its centre, from 1 foot to 18 inches in diameter, to admit of plumbing over a mark at the ground level, to which access was obtained through a vaulted passage. After a time...the hollow core gave place to a solid core.

On the Ranghir Series perforated pillars were built, around which temporary platforms were erected on posts at the time of observation. These pillars were found to oscillate with the wind; thus the arrangement was disapproved of, and it does not seem to have been adopted on any other series. It was, however, introduced several years afterwards in the modern triangulation, ... but with the precaution of constructiong walls of bamboos and matting round the posts...to protect the pillars from the wind[2].

On the closing of the North-East Longitudinal with the Calcutta meridional series "a much larger linear closing error was found than had been met with on any previous occasion". This was traced to the deflection of several towers near the junction which were proved to have deflected several inches, probably as the result of water penetrating into their foundations [19, 30, 106].

For many years this evil was not suspected, ... but eventually the magnitudes of the closing errors...as compared with triangulation carried over the hill stations made it only too evident that deflections must have occurred at some of the towers. ...

This tendency to deflection led to the introduction...of towers with central masonry pillars, perforated vertically, and having vaulted passages leading to the ground level markstone. Owing to this distrust of the towers and the inferiority of the instruments used, "the final reduction of the North-East Quadrilateral was set aside to be taken up after the completion of" that of the two adjacent Quadrilaterals [21][3].

Along the ill-defined banks of constantly shifting rivers many towers were washed away before they could be used, and many were the complaints of revenue surveyors who vainly searched some years later, but, writes Waugh, it was unfair to blame the Great Trigonometrical Survey when the country is altogether flat and subject to widespread inundation, as well as to shiftings of the river. ...

[1] DDn. 492 (136–9), SG. to R. J. Walker, 28–9–46. [2] *GTS.* II (46; pl. 2); VII (13). [3] *GTS.* VII (13–5, 276).

There can be no permanence where natural laws have ordained that the ground should be ever changing, and to complain of the loss of stations so situated is to quarrel with nature herself. Permanent towers could not be provided just to please the revenue surveyors;

Permanence could only have been secured by strong masonry towers such as were used on the Great Arc. ... Tower sites and station marks would always be found, and thus give permanent marks...for the revenue survey, and in case of the azimuth being required it could always be determined by ray-trace without using the towers. ... Colonel Everest...laid it down... that the elevated towers were only required for the continuous triangulation, and after this was established the towers might be removed or allowed to fall, because all the objects of detail measurement might be secured by reference to the ground marks [105]. ...

For the Calcutta Meridional series the number of towers...was 48, which would have cost 96,000 rupees if the permanence...had been made a principal object, whereas the actual cost was about 12,000 rupees. ... The towers of themselves have done their duty when the triangulation is finished and has closed satisfactorily [106][1].

TOWERS : EAST COAST

The erection of satisfactory towers across the low, flat, congested country south of Calcutta was a main problem of the Coast Series for several seasons. Several of the old towers of the Calcutta Longitudinal were brought into use [24];

The platforms, ladders, and other woodwork are more or less rotten, but the towers themselves appear to be uninjured. The tower at Dilakoss is an old semaphore tower, as is also the tower at Nibria [III, 264]. The towers at the base and at Bola are hollow square towers built purposely for the Great Trigonometrical Survey[2]. ...

At...stations selected this season...I have adopted the square hollow tower, but in the low marshy country on both sides of the Hooghly south of Calcutta the cost of materials for building is very great—the expense of carrying them enormous—not to mention the labour and difficulty of transporting heavy materials through a swamp, for the most part too wet for cattle, and too dry to admit the smallest boat to float[3].

During season 1847–8

Mr. James was detached with carpenters and bricklayers to make the necessary alterations in the platforms of the old towers at the north end of the base, Dilakos, Banibori (built in the season 1846–7), and at Nibria, executing at the same time such repairs as were needful to the ladders and other woodwork, and at the latter place putting up a new platform, the old one being much decayed and unsafe[4].

Waugh preferred earthen mounds to Hill's wooden scaffolds [23].

The objections to detached pillars with scaffolds are three-fold. 1st. They vibrate with the wind. 2nd. They are liable to deflect from the perpendicular. 3rd. The scaffold from yielding and straining is liable to come into contact with the pillar. ...

Mounds of earth thrown up round your pillars would form...convenient substitutes for towers. ... The most ordinary labourers can throw up a mound, whereas towers require brickmakers and layers, ... artizans difficult to procure in the jungles. ... If the mound and pillar be resorted to, the latter must be isolated for at least six feet from the summit. ... A well of wattle composed of poles and brushwood interlaced might be sufficient to relieve the upper part of the pillar from lateral pressure and...vibration from the tread of observers. ...

Never, under any circumstances, ... use a pillar without buttressing it with a mound to at least one half its height. ... In almost every case the pillars used in the Upper Provinces were found to deviate from the perpendicular. ... The best plan is to bury four external marks stones beyond the base of the mound, and duly corresponding with the lower central mark. The upper mark can then be examined...after allowing time for settlement [106][5].

During season 1848–9, writes Hill,

the towers progressed with considerable celerity, and although in some instances, owing to the quantity of salt in the soil rendering it unfit for bricks, ... part of the buildings fell and retarded the builders. ... In many cases the soil near the sites of the towers was either so sandy, or more frequently so deeply impregnated with salt, as to be totally unfit for making bricks. ... From scarcity of fuel for...burning them, kiln-burnt bricks cost considerable more than usual. Lime also is exceedingly scarce, and...had to be transported...from a considerable distance. ...

[1] DDn. 478 (7), SG. to DSG., 28–6–50. [2] Report on these towers, 1–6–68, DDn. 159 (91–103). [3] DDn. 593 (3), Hill to SG., 20–7–47. [4] DDn. 507 (41), Hill to SG., 11–7–48. [5] DDn. 506 (281), SG. to Hill, 7–9–48.

It has been found...necessary to increase the width of the stairs leading to the summit of the towers to...carry up the body of the 24-inch theodolite[1].

After Hill's departure and until Peyton took over in 1852 progress was frequently held up by the towers being badly sited, though Waugh did not agree with all of Strange's criticisms [26];

Solid towers have been used...on other series with complete success, being built according to the principles of their original inventor [Renny]. It does not follow...that if solid towers are carefully constructed and the upper mark scrupulously fixed, as it used formerly to be, that the result will be want of integrity. Finding, however, that...there was no certainty of an adherence to true engineering principles, ... I ordered the solid system...to be discontinued.

That it was adopted and persevered in on the Coast Series is no doubt a matter of...regret, but the repetition of angles and the test azimuths...afford satisfactory evidence of the excellence of the tower building. ... When the work comes to be finally tested by a measured base...it will be seen whether there is any reason to doubt the integrity of the stations. ... The only way to avoid uncertainty is to adopt perforated towers [107][2].

TOWERS: INDUS VALLEY

In the long stretch of eight degrees covered by the Great Longitudinal series to the borders of Sind, towers had been required at two stations only, and Strange had been greatly relieved to learn from Rossenrode that none would be required in crossing the "little desert" [39–40]. The plains of lower Sind and the passage of the Indus were another matter, and called for eleven towers of heights from 15 to 40 feet. When the Surveyor General found an unwelcome discrepancy between the measured length of the Karāchi base and the length computed by triangulation, he accepted the suggestion that this might have been due to uneven settlement of some of the central pillars, which had been built on artificial mounds with insufficient foundations [IV, 82–3 ; V, 42][3]. To ensure that there should be no such cause for anxiety on the Great Indus series, he advised Tennant to build all his pillars with a vertical passage, or perforation, from base to summit [107, 110].

In the year 1850, anticipating the requirements...in the desert of Sind, I issued elaborate instructions for building trigonometrical station towers [106]. ... Instead of laying down a single regulation plan to be followed without discrimination, ... I gave an account of every experiment which had been tried, with the advantages or disadvantages which had been ascertained, ... "but for new towers the means should be given for referring directly to the under-mark by a perforated pillar and vault" [106, 110, 112]. ...

The infinite variety of circumstances to which we are liable...may...warrant occasional deviations in special cases. ... It is not desirable to exclude the free exercise of judgement and skill on the part of scientific officers. ... No man with any pretensions to science can at any time say that the limits of perfectibility have been attained.

The qualities required in a trigonometrical station are ; 1st. Perfect steadiness and isolation of the instrument. 2nd. Indelibility and invariability of position in the mark. 3rd. Safety of the instrument. 4th. Facility of construction or economy of time. 5th. Economy of expense. 6th. Convenience of access. Perfection in all of them is not likely to be obtained simultaneously. ...

The Great Indus Series is a work of the first order. ... All the pains taken to observe angles to tenths of seconds, and obtain results defined in accuracy by fractions of an inch to the mile, would be utterly thrown away if settlements took place to the extent of 1 foot deviation in your marks, equivalent to 3 or 4 seconds in your angles. ...

I would recommend that where solid towers have been already erected exterior marks of reference should be fixed, ... and that the perforated tower should have a fair trial in future. ...

An important alteration has been introduce in the method of referring to the lower mark. ... The lower markstone, instead of being fixed by the builder, is left for the observer to insert. The builder fixes a plug of hard wood securely into the aperture at the summit. This plug has a fine hole drilled through it, small at the upper surface, say half an inch in thickness, and wider below. The signals are centered over this dot under which the observer afterwards fixes the lower mark by means of a heavy plummet or look-down telescope [106]. ...

[1] DDn. 593 (105), Hill to SG., 23–8–49. [2] DDn. 696 (254), SG. to Strange, 6–3–57. [3] DDn. 594 (253), Strange to SG., 9–7–55.

The anxiety to carry out the theory of isolation...has led to the practice of building the pillar for the instrument separate from the tower from the foundation, but the diameter...is too small for stability. Hence, unless the isolating cavity is filled up with sand, the pillar is liable to deflect. Sand...destroys the communication of forces calculated to disturb...the pillar; ... at the same time it affords that firm lateral support...to prevent unequal settlement[1]. ...

All the advantages of isolation can be practically secured by an annular vacuity of only 6 feet deep, to be filled with sand. The instrument shall...stand independent of the tread to persons on the tower, as...tested by...level and telescope. The level should not exhibit vibration, far less deflection, when two or three persons walk with heavy tread round the instrument., nor should the telescope when pointed on a fixed mark exhibit either tremor or deflection... when two or three persons stand first on one side, and then on the other. ...

Mr. Logan last year made his pillars 7½ feet square at base, and diameter at summit of only 3½ feet, the height averaging about 30 feet. He carried his masonry up square and perpendicular, the...batter being provided for by offsets at intervals. The upper 6 feet consisted of a round pillar isolated by an annular well.

The vault giving access to the lower mark was to be filled up by the last signallers using the tower;

If a perforated tower falls, that...cannot effect the mark on the ground, over which the debris will form a protecting annulus. If mischievous persons attack a perforated tower, the mark on the ground is not readily accessible because the vaulted passages are closed up. It is usual to cover the top of every tower—when it is left—with a mound of earth, and to cut away the ramp. All reasonable risk of mischief...might be effectually prevented by burying a lower markstone below the one on the surface[2].

Waugh describes in detail the procedure to be followed at a perforated tower;

The observer...will open out the vault—plumb the lower mark—and record any deviation which may have occurred since the tower was built. From this he can infer whether the stability of the upper mark can be trusted for the short remaining period required.

He will then efface the builder's lower mark, and engrave a permanent lower mark corresponding to the mark used by the signaller. If the stability of the tower can be relied on, the vault may now be closed up finally, otherwise there is no alternative but to centre both instrument and signal rigorously by the lower mark, using no intermediate plug whatever[3].

In May 1855 Tennant's assistant, Burt, came in from revising the lay-out of tower stations which Rossenrode had prepared two years earlier [45–6, 100];

He...had been much delayed by the rain, and a large number of kutcha bricks were destroyed. The masons have been very scarce, and few towers have...been got into proper order. ... Only three...will not require considerable repair, and two renewal entirely. ... It will be far better, and eventually less expensive, to re-select the series beyond...Maru Pir. ...

The towers at Mir Khan, Hairo, Maru Pir, are rebuilt, and Sabar Khan repaired, ready for the next season. ... Mr. Burt has done all that could be expected owing to the great scarcity of masons. The Hairo tower...has been the only one which has been built hollow. It was found impossible to build that at Mir Khan on this pattern as not a single mason capable of turning an arch could be got, ... and no member of the party had ever seen such a tower.

May I request the favour of your sending down one or two copies of the Roorkee treatise on brick-making and on building[4].

He estimated that about 120 towers would be required between Sukkur and Kālābāgh, and asked permission to engage a special establishment for the work, to include 6 bricklayers @ Rs. 10, and 6 brickmakers @ Rs. 7;

Inundated as a considerable portion of the country...generally is, it seems unlikely that tower building can be carried on during the season of the river's flood without injury to the health of the men employed, even if it be practicable at all[5].

Work on this section was suspended between 1856 to 1858, and these towers were built by Armstrong and Keelan during season 1858–9 [48–9];

The estimated heights of towers [writes Waugh]...are much higher than I should have expected. ... It is bad economy, however, to stint in height. ... It appears to have been a judicious measure on Mr. Armstrong's part quartering with his party at Sakar, close to the scene of operations. ... Mr. Rossenrode's towers were considered unsatisfactory by Lieutenant Tennant, who was inclined to attribute their failure to...inefficient contractors. If Mr. Armstrong employs the contract system the erection of the towers will require strict supervision[6].

[1] DDn. 592 (3), SG. to Tennant, 9–1–54. [2] ib. (25), SG. to Tennant, 6–3–54. [3] ib. (182), SG. to Tennant, 8–6–55. [4] DDn. 709 (222) Tennant to SG., 25–5–55. [5] DDn. 710 (98), 4–7–55. [6] DDn. 711 (55), SG. to Walker 2–6–58.

Keelan had many disappointments, reporting on one occasion that
a messenger came in yesterday from the lampman at H., informing me that the tower at that station had come down, and the pillar only was found standing. ... The tower came down two or three days after it was completed, and it is hard to say what was the cause, but I... believe that no precautions were taken for sinking a proper foundation, ... and further that the bricks were made of the same sandy soil, or...not sufficiently dry before being used. It is very disheartening, this occurring in the middle of the work, and just as the tower was wanted. It took 3, or nearly 3, months to complete it, and it is impossible to say when it will be ready[1].

When he came to observe at this tower a few weeks later
the rays...had to be re-cleared...as those cut by Mr. Ryall...were crooked. At the same time Jhangal Panora and Wasand were found to be refraction rays, the former requiring a scaffolding of 25 feet and the latter one of 17 feet before vertical observations could be obtained. ... It was after much delay I could collect and prepare materials sufficient—...timber, bamboos and rope—for so many stations simultaneously.

The tower stands on low ground and the rays to the surrounding stations pass either over high belts of land or banks of the numerous canals which abound in the district, and for which no provision was made in the height of the towers.

Walker comments unkindly that "Mr. Keelan seems to be bilious for he speaks of having to cut rays and erect platforms for himself as a hardship"[2].

TOWERS: PUNJAB

Scarcity of water was one of the troubles that cramped the building of towers in the Punjab. Walker writes to Shelverton who was working on the approximate series for the Jogi Tila series;

In your selection of stations, ... however, symmetrical a triangle may be, if one of its stations falls in the midst of a waste of sand, ... you will not be able to sink a well, and will consequently be compelled to send some distance for bricks, clay, mortar, and water [52–3]. ...

Your every workman must be brought from great distances, and...you will have to make arrangements for the carriage of provisions for them as well as for your own people, for which... you may have to send thirty or forty miles. ...

On selecting a favourable position for a station, your first care must be to have a kacha well sunk close by. These wells...may...be dug for about Rs. 30. In most cases, therefore, it will...be preferable to dig a well than to send a greater distance than one mile for water.

Be most careful not to choose very long sides unless you have the clearest proof that the towers built on them will become mutually visible at minimum refraction. The towers constructed by Dunlop are not, and cannot be made, mutually visible without resorting to the extraordinary and expensive process of raising each tower some 50 feet in height[3].

There was trouble on the ray between Kathiala and Hela [52–3]; Armstrong's tower at the former station had collapsed whilst under construction,
and if it were to be raised more than a very few feet it would inevitably fall down again. That at Hila has not met with any such mishap, and the katcha portion is very good and firm. But, unfortunately, Mr. Dunlop's endeavours to construct cheap towers led him into the lamentable error of neglecting to base the central pucka pillars on good foundations, or indeed to commence it at all until the surrounding kutcha walls were raised several feet. He then stretches 2-inch planks across the walls and builds the pucka pillar upon the planks, so that the most important portion of the whole structure is the least trustworthy. To raise the Hila tower therefore, it must be first pulled down, and rebuilt from its basement[4] [52].

For the Gurhagarh series running south through the Rājputāna desert, [51], Shelverton, who had now had many season's experience, warns his assistant that
our sides should never be shorter than nine miles and seldom exceed eleven. ... Unless your towers stand more than 50 feet above the surrounding level, and no obstruction intervene, ... a triangle with sides of 13 miles will only delay the progress of the final observations [101]. ...

The plan of tower with which you have been provided is...the most economical of any in use with us. The dimensions...are 24 ft. by 19 ft. at base; 20 ft. by 15 ft. at summit, and 30 ft. in height. The straight stair five feet...leaves at the summit a landing 5 ft. by 10 ft. for the instrument boxes, and a platform 15 ft. square for the observatory tent.

[1] DDn. 724 (235), 25–1–59. [2] DDn. 710 (253); Walker notes on Keelan's letter of 3–3–59. [3] DDn. 722 (113), Walker to Gen. Shelverton, 16–1–64. [4] Ib. (147), Walker to SG., 9–3–65.

The pucka perforated pillar stands on a plinth seven ft. square, and is generally built up to the height of 24 ft. by a succession of 3 cubes. ... The first of these contains the archway... for reference to the markstone, and the uppermost sustains a pillar six ft. high and 3 ft. in diameter, with an annulus of 2 inches which perfects the isolation of the theodolite. ... The perforation is a square opening of a foot over the archway, gradually decreasing to a hole six inches in diameter at the top of the pillar.

The materials required for a full tower of such construction are :—sun dried bricks, 12 inches by 6 by 3, 11,000—baked bricks...12,000—lime 20 to 30 maunds.

Where the soil is firm you never need to sink your foundations more than two feet below the surface, but on mounds which in this country are the cemeteries of the surrounding villages, you will find superficial digging very dangerous. ...

If...you engage a staff of six intelligent masons, and then take some pains...to point out what is wanted of them, you will find that they will soon understand their work. ...

When a tower is completed it is best protected from the effects of wet weather by plaistering it all round with a cement made of chopped straw and mud. To preserve the "terre-plein" at the summit, and prevent water from finding its way in...by the annulus, a mound of loose earth with an easy slope to the sides, and similarly plaistered over had been found sufficient.

Every full tower should be buttressed all round to the height of at least eight feet with clods such as are used by the villagers...to build up their walls[1].

PLATFORMS & MARKS

The first essentials of every observation station, whether on hilltop or tower, or otherwise, was the stability of the instrument and the immobility of the mark over which instrument and signals were centred. The mark itself was a dot with a concentric circle, cut on stone by means of a pointed chisel. If the mark can be engraved in situation so much the better, otherwise a large stone—properly marked—ought to be buried in the ground. Over this a small platform is raised, on the summit of which another markstone is inserted and fixed truly vertical over the lower one. ... Measurements and observations are usually referred to the upper mark, and are so recorded in the angle-book records. Sometimes...it is necessary to raise the platform to a considerable height, in which case several markstones are...inserted and their relative heights recorded. ...

For principal stations it is necessary to make that part of the platform on which the instrument rests separate and distinct from that on which the observer and his assistant walk. The instrument is then said to be duly isolated. ... The annular space between the observer's stage and the central pier should be filled up with gravel or sand, otherwise screws or other parts of the apparatus may be lost.

Besides the uppermost stone it is usual to imbed in the pier three picked flat heavy stones for the tripod...to stand upon. These are called feet stones, and they should be duly levelled. In localities where the ground is very unsteady, such as deep black cotton soil, I have found it practicable to steady a theodolite by using pickets 4 or 5 feet long, and driving them into the ground for the stand...to rest upon. ...

As soon as all the observations have been taken at any station, and it has been observed from all the corresponding stations, it is no longer required for the purposes of the trigonometrical survey, and it should have a pile of stones, with a pole and brush erected over it in order that it may be visible and useful to the detail surveyors[2].

Strange had the pillar built of stone in lime mortar [27], and the platform...oriented so that the observatory tent may always be pitched with the slit...conforming to the meridian. The platform is to be never less than 16 feet square. This admits of room all round the tent for the man employed in flashing out the signals.

The upper markstone is merely a convenience obtained at some risk of error, unless the greatest care be taken in fixing it vertically over the lowest mark, and in ascertaining the distance between the two. ... The lowest mark alone constitutes the true station[3].

Waugh noted that Colonel Everest and Captain Jacob both advocated dry stone masonry. I have seen some beautiful specimens of these. ... The use of... stones with mud cement has been very generally condemned, ... but the great principle is isolation. If that be rigorously carried out, defects in other parts will be less influential.

[1] DDn. 695 (99), Shelverton to Clarke, 17-11-59. [2] DDn. 601 (1), Topo. Instns. 1853 (6), no. [3] ib. (164), Strange to Rossenrode, 26-2-56.

The practice of building platforms during the progress of the work is in itself, however, a fertile element of evil. ... All construction processes...are more or less liable to settlement. ... After a long lapse of time, if a platform looks sound, and there is no apparent cause to doubt its stability and steadiness, a judicious geodesist would not disturb the upper mark. ... If he was compelled to disturb that mark for the purpose of reconstructing the platform, and found a want of identity between the upper and lower marks, he would adopt the latter. ...

I cannot understand how the duty of building platforms got divorced from the approximate series. That undertaking always included all preparative arrangements whatever [99][1].

Robinson found that one of the principal stations of the North West Longitudinal series on the Ravi River had been tampered with [210, 469–70];

At Pagwansir I was delayed 5 days. Some fool or scoundrel had dug up and carried off the markstone. Fortunately I found the lower markstone correct and firmly bedded, and as I had to rebuild the station, I took advantage of the opportunity to raise the whole eight feet higher. ... Platform isolated[2].

Important stations were usually handed over to the civil authorities when all connections had been completed, and the Surveyor General directed Renny to see to the "preservation of the observatory and station of Kalianpur" when starting the Great Longitudinal series [IV, 98 ; V, 98]. Renny duly reported that

as regards the observatory and adjoining building, all the woodwork of the doors, windows, and meridional aperture, has been deposited inside the buildings, and the apertures closed up with stone and mortar. ... The meridional aperture in the roof has been closed in with sandstone slabs. The upper half of the steps...leading to the roof...has also been deposited inside the observatory, but the wood is...unsafe for future use.

The station marks on the platform and meridian pillars have been covered over by domes of masonry, with a hollow space round the marks to admit of their being again available. ...

A paper written in English, Persian, and Mahratta, explanatory of the object of the observatory is placed inside on the pillar, and a similar document enclosed within a bottle lies under the dome of the station platform. ... The guard furnished by the Nawab of Tonk...was removed...on the 25th of November last, ... the day after my arrival[3] [469].

In 1866 it was ordered that all stations of the Great Trigonometrical Survey should be placed under the official protection of district magistrates, and visited periodically. Reports on their condition were to be submitted annually to the Superintendent Trigonometrical Survey[4]. In pursuance of this order a revenue assistant[5] was specially deputed to give suitable protection to the markstones of 48 tower station of the meridional series falling in the North-Western Provinces, and hand them over to village authorities. Similar arrangements were carried out in other parts of India[6].

[1] DDn. 691 (94), SG. to Strange, 12-8-56. [2] DDn. 731 (20), to SG., 2-3-51. [3] DDn. 516 (177-8), 23-4-49; tho' in excellent preservation in 1866, the observatory no longer existed 50 years later. [4] DDn. 15 (62), DO. OTS., 15-1-66. [5] Wm. Ivey [441]. [6] *GR. Trig. 1865–6* (5, 21).

CHAPTER IX

OBSERVING & COMPUTING

FINAL ANGLES — *Changing Zero — Observatory Duties — Signals —Secondary & Minor Triangulation — Charts —* COMPUTATIONS: *Forms & Formulae — Auxiliary Tables — Logarithm Tables — Initial Elements — Geographical Positions — Field Parties — Records & Reports — Dispersal of Errors.*

The preliminary work of the approximate series called for considerable experience, good judgement, and adaptibility to local conditions, and was essential to the execution of the final observations. Nothing whatever could be left to chance [26, 100]. Though these final observations were invariably undertaken by the officer in charge of the survey yet they were by comparison a mechanical process, requiring the most scrupulous attention to minutiae. Indeed to the average active man high-class geodetic observation can be the most tedious of occupations. On the other hand, it is the actual observer who "calls the tune". He it is who not only organizes and directs every item of the preliminary work, but is also the final arbiter of its sufficiency and completeness. An experienced and efficient observer would never commence work until he had satisfied himself—

(*a*) that all stations had been wisely selected to effect the very best layout suited to the ground [100].

(*b*) that he would have a clear line of sight to each station of his programme, and that each station was provided with suitable signals, properly centred over a permanent mark, and manned by efficient signallers.

(*c*) that the station from which he was observing, and those from which he would shortly observe, were properly constructed, with a permanently fixed mark-stone, and a rigid pillar for the instrument, isolated from the observer's platform.

(*d*) that his instrument, accessory lamps and other gear, were all in perfect working order, and that his recorder, if he had one, was fully competent.

The setting up, levelling, and adjustments of the instrument, the intersection of the signals, the reading of the scales, the changes of face and zero, were matters of routine, calling for the greatest patience, precision, and concentration, in all conditions of weather and atmosphere. The recording and reduction of observations followed strict rules that showed up the quality of the work and any irregularities that called for investigation and possible re-observation.

Everest had laid down detailed procedure, and Waugh was strict in its enforcement. Most of the changes that he introduced were to meet the idiosyncrasies of new instruments. He regretted Shortrede's departure from

the system of uniformity prescribed by my predecessor, because established forms and methods of procedure are indispensable. ... Your operations...form but a small portion of the entire system of triangulation every part of which should...be exactly similar, so as to be capable of combining together into a complete and harmonious work. ...

All the other series have hitherto been executed upon one uniform system, so that your work will form a solitary exception. ... If a deviation from rule be permitted in one instance... there is no calculating the extent to which innovations may be carried.

Some may go on multiplying the number of zeros for the sake of increased accuracy, while others may...reduce the number in order to obtain credit for economy at the expense of precision. ... Some...will...introduce innovations for the mere love of change [392]. ...

I am placed in an awkward position in forming a decision upon the work executed by you. ... If...it be rejected...the cost of...repetition would not be less than 20,000 rupees, in addition to which...the completion of your series would be postponed as least a twelve month. ... I have

decided to retain the work, and will make provision for its informality by a specific explanation in the preface of the 10th volume of the General Report[1] [11, 132].

On the introduction of the new 24-inch theodolites [152–4], the Surveyor General issued a departmental order, of 8th July 1848, laying down "Rules regarding Observations", superseding Everest's order of 13th February 1843.

CHANGING ZERO

Under Everest's rules for the 3-ft. theodolites, readings on 5 microscopes were spread equally round the graduated circle by means of three rounds of angles on each of four settings, or three changes of zero by arcs of 9° which, being repeated on both faces by reversal of the telescope, gave 24 independent observations [III, 258 ; IV, 90 ; V, 98][2]. It was Shortrede's departure from this rule which had led to Waugh's remonstrance [114]. He had observed

at every 5° instead of...at every 10° of the limb. I was led to adopt this...on account of the unsatisfactory manner in which the limb has been graduated. I found that angles taken on different parts of the limb differed sometimes more than 40″ from each other. ...

No dependence could be placed on the observations of single faces, and...the division of the limb was such that the two faces were not really independent. I found that by taking the mean of the two faces the discrepancies among the angles were generally only about one-fourth of what they were on opposite faces. ...

The division being manifestly bad, it seemed desirable to multiply the points of observation. ... Notwithstanding all these precautions, the angles at most of the stations are not so accordant as could be wished. From the first I attributed this to some mechanical defect, ... but it was not till I got to the last two stations that I satisfied myself entirely as to its nature[3].

Waugh's objected to any such departure from standing rules [392] ;

The innovations...introduced are not so objectionable in reference to professional accuracy as to departmental uniformity. ... No one can doubt that an increase of the number of zeros... must produce a corresponding degree of precision, ... but...at the sacrifice of...time and money. The number of zeros prescribed by my prececessor was decided upon after mature consideration, ... and...a considerable increase upon the practice of former years. ... Observation at every 10° will afford a rapid approximation to the truth, ... and...any increase to the number of zeros can only affect the mean result by a minute fraction of a second.

I am an advocate for the repetition of angles at the same part of the limb because the coincidence which such observations ought to exhibit affords the sole means at the observer's disposal for testing the state of the instrument and the quality of the work while it is in progress. Any mistakes that may be committed are also more certain of detection, ... and the remedy may be applied while the opportunity is within the observer's power. ...

Your system of taking a single observation at each zero transfers the responsibility of all errors to the account of the graduation[4].

In 1847 he put in hand a series of experiments to ascertain the very best system for changing zero when using the new 24-inch theodolites [153–4]. He set five observers to observe with various settings and wrote to Du Vernet ;

Experience shows that angles taken at different zeros with a 24-inch instrument vary as much as 8″ from each other, while the 3-feet theodolite gives variations not exceeding 2″ to 3″. This fact clearly indicates that a greater number of changes of zero is required to reduce the errors of graduation in the smaller instrument than in the larger, ... and I think it will be absolutely indispensable in a work of so much importance as the North-West series to take with the 24-inch theodolite 24 angles distributed over 6 changes of zero, and as there are 5 microscopes we shall thus obtain readings at every 6° of the limb[5].

He also introduced the practice of changing "likewise the minute, ... whereby the readings will fall on different parts of the (micrometer) screw, and the error of the run be in some manner compensated". He asked Renny to experiment on the TS. 3-ft. theodolite with various settings, still keeping to the total of 24 readings, and he writes to Strange later that

in my opinion the number of observations, 24, is ample. ... To increase that number would

[1] TS. 10 ; DDn. 491 (20–8), 31–3–44. [2] DDn. 616 (8), SG. to Renny, 16–9–48 ; *Merdl. Aro.* (CXVII–XVIII). [3] DDn. 521 (58), Shortrede to SG., 22–2–44. [4] DDn. 491 [(20–8),] SG. to Shortrede, 31–3–44. [5] DDn. 492 (58–71), 12–6–47.

cause immense delay and would only slightly modify the results. The practice of repeating angles 3 times on the same divisions conduces...to extreme perfection, ... for nothing but scrupulous care and delicacy can produce 3 accordant results, whereas when 2 observations only are taken their accordance may be fortuitous in half the number of cases. ...

The advantage of Colonel Everest's rule can hardly be over-estimated, for it has the effect of making almost any man a skilful and painstaking observer. The question is whether, when an observer has been trained, it is safe to relax the rule[1].

Strange reported at the end of the season that he had good results from the reduced number of intersections which he continued so long as he was working on a double series ;

It seems to me that under general circumstances two intersections on each face are sufficient, provided the observer's integrity be undoubted, and his skill such as to justify his being entrusted with a first-class instrument. ... I have made it a general rule...not to consult the angle-book until after the completion of each face[2].

After examining these experiments Waugh enunciated a law governing the effects of multiplication of observations ;

I consider all graduation...to be subject to two errors, one casual, the other following some law of distribution. The discovery of a law of error in graduation is entirely my own, and has never, that I am aware of, been put forward by any geodesist. These errors we seek to eliminate by regular systematic change of zero, which is Everest's system. Error of observation, i.e., of intersection and reading off, is eliminated by the multiplication of observations. ...

The casual error of graduation will obviously be eliminated by a sufficient number of regular changes of zero by equal arcs, but it does not follow that if a law of graduation does exist that regular changes of zero will eliminate all its effects. ... Changes of zero ought, in my opinion, to take place in uneven numbers, whereby we shall gain the advantage of fractional quantities. For this reason I introduced the system of 5 changes of zero with 10 faces instead of 4 changes with 8 faces[3].

OBSERVATORY DUTIES

The work of the observatory assistant in handling the instrument, managing the lamps, and recording the observations, was most important, but the Surveyor General protested more than once against the practice of keeping two assistants for these duties. Du Vernet justifies himself ;

I have occasionally, unassisted, measured final angles with a grand theodolite having five microscopes, but the work is more than one observer can properly perform, and necessarily much time is lost. ... The hours of observing in this climate [Assam] being limited to one or two hours before and after sunset, I request that I may be always allowed the aid of one of my assistants in the observatory in addition to the one writing the angle-book[4].

Strange, on the Coast Series, was equally insistent ;

The principal operations cannot progress with that vigour which you so much desire unless I am accompanied by an additional assistant to assist with the observations. ... Not a raw untrained hand, but as skilful an observer as possible. ... The instrument has now 5 micrometers [153]—the climate is extremely unfavourable to observation—and health is not to be reckoned on from one day to another. ... The only way...is to have two trained observers with the instrument, both to accelerate the observations generally, and as a provision against sickness. ... [No fewer than 80 days had been spent at six stations].

I should have been able to accomplish certainly double that quantity with the help of a qualified assistant, for not only would the observations be taken more quickly with such help, but greater advantage could be taken of the intervals of fine weather...which are generally very short, and are usually succeeded by much longer intervals of bad weather.

The Surveyor General was insistent on the neatness and legibility of the original angle-book, and protested against describing the second copy as the "fair copy" ;

I conclude that the original observations were first recorded roughly, and afterwards copied. This practice has been...discontinued...for many years because it was found to be a needless waste of time, and not so worthy of confidence as the present system. Two books are now kept, and they are called the "original" and "duplicate". Since the habit has obtained

[1] DDn. 616 (35), 8-9-49. [2] DDn. 594 (63), 1-5-50. [3] DDn. 691 (94), SG. to Strange, 12-8-56; cf. suggestions made by Tennant, DDn. 710 (70), 8-1-55. [4] DDn. 602 (165), 25-6-53.

of observing slowly, with the view of avoiding the evil effects of lateral refraction, the writer of the angle-book finds no difficulty in bringing up the original record in a hand fair and legible, and clerical errors seldom or never occur[1].

Referring to departmental order of 7th May 1852, he reminds Strange that it is a standing rule...that nothing done by one person is considered perfect. As...one observer and one writer compose the establishment of a field observatory it becomes the special duty of the observer to check the angle-books regularly after each period of observations.

I used to do this between zeros while my assistant levelled the instrument, and after the morning's work, always clearing off the examination of each day's observations before another day commenced. ... You will...check in pencil both in the angle-book and observatory memo. book, and if the writer...agrees with you be will ink in ; if not, you will both examine. ...

The column of mean micrometer readings and deduced angles must be attested by both parties, and each page must be attested by the observer[2].

Amongst the precautions for accuracy was the determination of value of the theodolite level scale, and the Surveyor General was indignant when he learned of the slovenly way in which Clarkson had tested the levels of Saxton's instrument ;

The proper...procedure...should be well known to a sub-assistant of your standing who aspires to...the charge of a Series. ... Had you kept up your general scientific knowledge... you could not possibly have adopted a system so much opposed to all sound principles. ... You could not have failed to suspect from the wild discordancies that something was amiss, and might have applied for information and instruction. ...

My detailed Instructions for the Trigonometrical Survey...was written expressly for officers of small knowledge and experience. In those instructions the method of determining the value of a level is given at page 27, with a form and example[3] [63, 98 n.3, 286].

SIGNALS

Even when preliminary work had been carried out with the utmost care the observer might be held up for long periods by vagaries of weather and atmosphere—dust—smoke—refraction—mirage. As a general rule visiblity was best at night when observations were taken to lamps [III, 246–8 ; IV, 87–9], but under Waugh's vigilant care vertical angles were restricted to the early afternoon [63–5]. Strange reports constant delays on the Great Longitudinal series ;

At Gopalpoora H.S. the air was so obscured...that not a single observation could be taken during 5 days. I determined upon not further protracting my stay there lest I should be too late for a favourable star which I wished to observe at Arumlia. ... Although so early in the season (being the end of January), the dusty weather had set in, and the state of the atmosphere could not...be depended upon for 24 hours. I have never seen dust so thick. ... Objects two miles off were often scarcely discernible, and heliotropes failed to penetrate it[4]. ...

I will give a few instances of the difficulty of marking points. ... At Gouroosikkar H.S. I sent a man with the reference lamp to take up a point on Mt. Aboo about 2 or 3 miles distant. He took two whole days to reach it. The same thing occurred at Kanenagar H.S.

At Marwar a man was sent to set up a pole and brush on a point about 6 or 7 miles distant ; the pole was not seen until the 4th or 5th day, and then on the wrong point. A signal party took 10 or 11 days to go...a distance of 18 miles. ...

This delay was owing to several causes, such as the difficulty, and in many instances the utter impossibility, of obtaining the name of a distant point or of any village near it, except on the spot itself—the badness of the guides, who constantly ran away leaving the men in the midst of a trackless mountain waste—the great similarity of the peaks and ridges to each other when near them—to which may be added the absence for many miles of villages—and the want of intelligence and willingness to assist that characterised the inhabitants generally. ...

In many parts...it would be quite unsafe to detach parties of even two or three men. All my signal men were escorted by two sepoys to each party, by the advice of Subedar Chater Tewaree, who knew the country well, and to this protection they owed their safety [39][5].

Waugh writes to Rivers who had reported difficulties in Kāthiāwār ;

The difficulty of seeing the signals may arise...from inadequate height of towers. This can easily be ascertained by raising a slight bamboo scaffold on the tower, which will enable

[1] DDn. 491 (20–8) to Shortrede, 31-3-44. [2] DDn. 592 (375), 1-12-55. [3] DDn. 598 (148), 1-9-51. [4] DDn. 594 (63), 1-5-50. [5] DDn. 615 (103), 6-8-51.

a man to watch for the heliotrope or blue light. Keeping the signal in view while descending, he can determine the exact height at which it will be visible. ...

In the plains we have generally found lamps and heliotropes very easily taken in ordinary weather at distances of 10 to 12 miles. Beyond 14 miles lamps are seldom takeable except in very fine weather. ... But if the ray runs sufficiently clear off the ground the heliotrope is generally takeable up to 20 miles in ordinary weather.

Last month I visited a party who were revising two old triangles of 20 mile sides in the plains, and the heliotropes were distinctly visible, but lamps—though seen—were not takeable on account of smoke. The towers, however, were forty feet high on mounds of 30 to 50 feet. ... As it was, the observations occupied about 8 to 10 days. On the Great Arc Colonel Everest had some rays in the plains exceeding 20 miles, ... but such extremely long rays are very unsatisfactory, and I advise 10 to 12 miles as an extreme limit [46, 101–3]. ...

During the cold weather and the sugar harvest we have always found lamps invisible or untakeable on account of smoke, so that the progress...depends at that time on heliotropes[1].

He explains to Clarkson that a perforated screen would not improve the sharpness of a heliotrope signal;

A small aperture...limits the intensity of the light, whilst the apparent size of the image depends almost entirely on the state of the atmosphere...which cannot be counteracted. If the disc appears large...it is the result of diffraction caused by vapours in a state of agitation.

The apparent centre of such discs are the true centres for observation. If the appearance... be columnar, it is caused by mirage or reflection from sheets of vapour slightly ruffled, similar in fact to the reflection of the moon from the surface of a rippled sheet of water. There are then a succession of images one below the other. ... The upper disc is the true image refracted through the air, ... the centre of this imaginary disc is the true centre for observation. Such observations, however, are attended with some uncertainty[2] [IV, 107 ; V, 57, 62–5].

SECONDARY & MINOR TRIANGULATION

Secondary triangulation was that which supplemented the principal triangulation for picking up important topographical detail in the nature of towns, hill ranges, distant peaks, or rivers [IV, 108]. Being intended for purely local purposes it was not generally subject to the rules for principle triangles, such as observation of all three angles or correction for spherical excess.

Miner triangulation was the term applied to continuous chains of small triangles run for the purpose of laying down the position of important towns, surveying the course of a main river, or making junction with a local revenue survey. Being carried out rapidly by light instruments it formed an economical means of extending trigonometrical control, and every principal series was expected to throw out such branches whilst other secondary points were fixed by direct observation from the principal stations [120, 186].

Of the more important of these series may be mentioned the surveys of the rivers Son, Gogra, and Gandak by officers of the Hurilaong Series between 1847 and 1852—survey of the Ganges by various meridional series over several seasons, making a continuous survey between Cawnpore and Bhāgalpur—survey of the Orissa Coast from Balasore to the Chilka Lake between 1857 and 1859—a chain of triangles from Cuttack to Sambalpur by Nicolson of the Coast Series and Dyer of the Ganjam party—observations of the snow peaks taken from principal stations between Peshāwar on the west and Purnea on the east—and from the secondary extension round Darjeeling carried out by the Surveyor General himself.

Several chains of minor triangles were carried out by the Bombay party in Gujarāt and Kāthiāwār, one of which, the Sābarmati series, was an abortive attempt to make connection with sea level on the Gulf of Cambay [57, 72–4]. Other chains were run through the Punjab between 1848 and 1853, not only to connect up the revenue surveys and important cities such as Lahore, but also to survey the main rivers [36–7, 273]. Extensive secondary work was carried through the North-West Himālaya and Kashmir for topographical purposes.

[1] DDn. 718 (169), 23-4-51. [2] DDn. 493 (306), 7-6-50.

Trigonometrical control was necessary to make the revenue surveys of lower Bengal, the North-Western Provinces and the Punjab, available for topographical and geographical maps, such control being required both for surveys already completed, and for those in progress [IV, 288–90 ; V, 3, 131]. Field parties were reminded that a certain proportion of secondary triangles should accompany all principal work. The stations of the principal triangles very rarely coincide with known points of any prior survey. ...

Besides the secondary stations...in the immediate vicinity of the operations, I wish all cities, cantonments, or other remarkable places to be duly connected by minor triangulation provided they are...within 20 or 30 miles of the...operations [IV, 24 ; V, 261, 295–6]. ...

Considering the number of assistants now attached to each series, no difficulty can be apprehended in determining the positions of a moderate number of secondary stations each season. ... The ray-tracing surveys should all be...reduced to order with the view of adding to our topographical knowledge [IV, 80–1 ; V, 103][1].

On the Karara series, Du Vernet's attention was called to the utter isolation of the triangulation which has frequently been entirely disconnected with the details of all prior surveys. Secondary triangulation is the only effectual remedy, ... and the ray-tracings will accomplish the same object, although in an inferior degree.

The principal stations being named after the nearest village are apt to mislead the compiler. ... A register should be kept of the angle subtended between the referring lamp and the village, ... or...between some principal station and that village. The distance of the village should also be measured by rolling a perambulator to its centre and back again. ... Every effort should be made to lay down by small triangulation any important places such as Roy Bareilly...and generally all places marked by conspicuous objects such as temples and minarets[2].

Again, another circular ;

Secondary triangulation in the plains should...be taken without towers or ray-cutting. Occasionally a platform 4 or 6 feet high may be necessary, ... and removal of a tree now and then, but...the work should be so skilfully arranged as not to require much aid of this nature. Sides from 2 to 4 miles long seem well calculated to secure every object of topography without expense or delay. Four sets of observations taken with the 7-inch or 12-inch theodolite will be ample at each station, ... distributed over 4 zeros. ... One observation at each of the four zeros appears to be sufficient. ...

The system of minor triangulation on which the details of the Great Arc were laid down has met with...approbation ; ... a series of small triangles emanating from a principal station, and terminating at another, ... the distance...derived from the principal stations [IV, 80–1][3].

For Logan's work through the *tarai*, where it was difficult to get a second ray to many of the villages, Waugh agreed that places laid down by a perambulator distance and an azimuth angle...possess a very high value, as their identity is beyond dispute, and their position must be determined to about 1″ of the truth, even when the measured distance amounts to 3 miles.

Your ray-traces were of course computed during the progress of the approximate work. All that is necessary now is to reduce them for the error in length and deviation as determined by your final work. The ray-trace will then...coincide with the true rays[4].

For Robinson's survey of the Jammu boundary Waugh's instructions laid down a procedure eminently suited for control of topographical surveys [286–7] ;

It will be proper to carry a chain of minor triangles along the boundary, with one flank resting on that line, or as near it as practicable. ... Thus the boundary traverse will be checked by your triangulation, which will itself be verified at intervals by connection with Mr. Logan's great series, on which your work will finally close at the Jhelum. ...

The points of your triangles will be valuable hereafter to the revenue survey and proposed contouring parties [67–8], on which account your stations must be carefully marked. ...

When the boundary survey is satisfactorily finished, you will...take up a side of Mr. Logan's triangulation on the Jhelum. ... From thence you will carry a principal series of large triangles arranged in simple quadrilaterals or polygons following the Salt Range to Kalabagh.

This series must be executed with scrupulous care, for on it will depend the exclusion of accumulated error, and it is to form a basis for the topographical operations. These will consist of secondary triangles depending on the sides of the principal series in such wise that fixed points of reference may be established over the country...at intervals corresponding to the character of the ground. Distances of 4 or 5 miles or under will suffice in hilly uncultivated tracts, but where the ground is valuable the fixed points must be more numerous[5] [231, 289].

[1] DDn. 499 (35–6), DO., 12–9–44. [2] DDn. 523 (79), 26–2–45. [3] DDn. 723 (1), DO., 28–2–45.
[4] DDn. 499 (75–6), 24–7–45. [5] DDn. 588 (37), 28–9–50.

He complained that Strange's triangulation chart did not shew enough geographical detail; "I cannot...exactly trace the Arabulli Range". Strange thereupon sent McGill, an assistant with topographical experience [421] to accompany the approximate series in advance, and to throw out secondary points on either flank from the principal triangles and he intended to mark these secondary points with masonry pillars. For his secondary work in Sind he used subtense measurements [14, 41–2, 72];

The country...was particularly adapted to this method. It is so perfectly flat, and so covered with jungle and vegetation that it was seldom possible to obtain a base for secondary operations...without going to the expense of artifical elevations. ... It is intersected in every direction by canals which rendered the perambulator next to useless. ...

One of the chief difficulties consists in obtaining a clearly defined point at either end of the pole. ... We at length decided in favour of...a circular disc of white cardboard, 2 inches in diameter. These discs take off and on. ... The distances between the centres of the white discs...forms the given length of the pole, ... 20 feet, the poles being merely bamboos. These discs were visible with the great theodolite generally at about 2 miles, but under favourable circumstances...at upwards of 3 miles.

He described precautions for setting the pole at right angles to the line of sight, and for the prevention of sagging. He preferred the horizontal position to the vertical. The Surveyor General thought that the difficulty of obtaining an exact measure of the subtended angle greatly restricted the value of the method;

Colonel Everest surveyed Java by means of a telescope with micrometer, no other implement being available [II, 137]. ... The late Lieutenant Walker adopted an analagous method... for ray-tracing in a country covered with impenetrable grass jungle [14]. ... For ray-tracing... the accuracy of direction of the ray...depends inversely on the number of intermediate stations, and the...method of subtense would require...a number of intermediate supplemental points[1].

On the other hand he welcomed Nicolson's proposed to supplement his secondary and minor work in Purnea with a planetable [288].

He later directed that the Assam series should lay down all places of major importance with a view of making sound connection with local revenue surveys. He repeated these instructions to Lane in 1858;

I wished you to fix near Goalpara, Gowhati, and a few other capital places, one or two permanent marks of reference as points of departure for detail surveys. Failing pukka buildings already in existence, a special platform built of the best masonry in a conspicuous position, covered by a mound of earth with a markstone at top, will best answer the purpose of leaving behind a permanent point of departure of unmistakeable character[2].

A similar scheme for providing permanent reference points at suitable points throughout India was suggested in 1945 but was far too great a task to be practicable.

TRIANGULATION CHARTS

Officers in charge of trigonometrical parties had to submit a chart shewing their progress every season, and under a departmental order of 1854 this annual chart had to embody the results of the field computations. Along each ray its length was entered in logarithm of feet above the line, and in number of miles below. Azimuths were entered at either end. Latitudes, longitudes, and heights were entered against every station, with a fine meridian line where azimuths had been observed. "By this arrangement...the materials become immediately available for compilation in my office, and for transmission to the Hon'ble Court of Directors" [127]. Secondary work was to be included, the purpose of the chart being—

1. To furnish means for incorporating existing geographical materials. ... All the important places within the scope of the series must be fixed, particularly the chief places on existing maps and, where the Revenue Survey has preceded, their trijunction marks are required. ...

2. To furnish a basis for future surveys. To this end the precise character of secondary points must be recorded, so that the surveyors may be able to find and refer to them. The

[1] DDn. 616 (53), Strange to SG., 9-7-53; reply, 691 (330), 29-7-53. [2] DDn. 591(203), to Nicolson, 21-7-52; 65 (11), to Lane, 9-8-58.

accuracy and identification of secondary points is of more consequence than their number, which may be moderate [230][1].

In 1856 a further departmental order was issued distinguishing three classes of charts—Approximate—Preliminary—Final.

In some parties approximate operations have degenerated into a rough sort of desultory reconnaissance, liable to errors and...unlimited alteration. These...are unauthorised innovations; ... they may be termed approximate operations for an approximate series.

Charts of work of this order, however valuable in the field, are in my office not worth the paper they are drawn on. Yet such work has been submitted, so elaborately projected and neatly printed as to be mistaken for final charts, and until they are burned or destroyed the Surveyor General can have no rest or peace of mind. ...

No provisional charts whatever shall be submitted...unless for the purpose of soliciting orders. ... The Surveyor General...has never yet met a case where a reference of this kind has...exhibited anything but the indecision of the executive surveyor. Should any case arise requiring the Surveyor General's opinion, the fact must be unmistakeably set forth, and the charts that accompany the letter...shall bear no semblance of a final character. With this exception, the Surveyor General...does not wish his office to be burdened with any provisional charts. ... The daily business is more than the Surveyor General can well get through [345].

The *preliminary* charts must be carefully prepared. ... If mixed up with approximate... work the chart will be destroyed. ... The numerical data must be fully and completely engrossed, and...attested by two signatures as correct. ... The preliminary charts sent from some parties have been found so badly drawn and printed, and so full of mistakes, ... that they have been...re-executed in the Surveyor General's field office for the credit of the Department[2].

Final charts for inclusion in the manuscript reports of the Great Trigonometrical Survey were prepared in the Surveyor General's field office at Dehra Dūn, or at the computing office at Calcutta.

A valuable chart of the Great Trigonometrical Survey was compiled at Dehra Dūn in 1857 on the scale of 32 miles to an inch. It shows all triangulation from the days of Lambton, topographical as well as trigonometrical, with areas of detail survey based on such triangulation. It gives the names and heights of all principal stations, and all the rays by which the Himālayan peaks were intersected[3].

A reduction from this to scale of 96 miles to an inch, was first published with the trigonometrical *General Report* of 1869–70, and showed also lines of spirit levelling and the positions of astronomical and pendulum stations. This was revised in 1882 and again in 1892[4].

COMPUTATIONS; FORMS & FORMULÆ

Everest had reduced his computations to a regular routine, adapting his rules and formulæ to the requirements of the Department. He allowed no unauthorized departure from these rules, though he was always ready to consider suggestions, more especially from his chief computer, Joshua De Penning [IV, 430–1].

The observer had first to abstract the means of the angles observed, and deduce the angle that was to be used for computation on a set form;

It is a distinctive feature of...this Survey that all the measurements of angles have for the last half-century been conducted under a system...which has been rigorously enforced and never departed from in principle, though it has occasionally been modified in detail.

For about a score of years at the very outset of the operations the observations were unsystematic, but very shortly after Captain Everest entered the Survey as an assistant to Colonel Lambton the system of taking the observations at each station over a certain number of equidistant graduations of the circle, and making at least two measures with the microscopes standing over the same graduation, was introduced at Captain Everest's suggestion, and it has been maintained up to the present time [1875][5].

From these deduced angles the surveyor set up and computed his triangles and vertical angles whilst work was proceeding. The computation of latitudes, longi-

[1] DDn. 455 (210–2), DO., 1–6–54. [2] DDn. 696 (172), DO., 15–9–56. [3] *v.* OD to B., mil., 2–1–57 (21–3); *IO Cat.* (31), ms.; printed at DDn. in 1955 under ref., 1915 ND '54–12 '55. [4] *IO Cat.* (32), further reduced, Markham (109). [5] Gen. Walker, *GTS.*, II (81).

tudes, and azimuths was left for recess quarters. On completion of the whole series the Surveyor's computations were sent in to the computing office at Calcutta, and there checked through and taken out in final form, adjusted with adjacent series, and completed as the official Report for that series.

As work proceeded Waugh introduced various changes into some of Everest's forms and formulæ, as, for example, the forms for computing geographical positions, astronomical azimuths, and heights[1], and special formulæ for various types of polygons. In making these changes he was greatly indebted to Radhanath Sickdhar.

To facilitate uniformity it was Waugh's constant endeavour to get several field units recessing together [370]. Everest had always spent the rains at Hāthipaon, with two or three field parties at Dehra or Mussoorie, whereas Waugh's parties were at first working further east, some recessing at stations such as his own headquarters Allahābād or Dinapore. Such close liaison was impossible to obtain with the Bombay party or the East Coast series, and when Rivers sent in his computations of the Southern Konkan series Waugh found much to complain of [392] ;

> The form of computation you have employed...was...introduced by Captain Shortrede. ... This form, though convenient in some respects, is not so well suited to the wants of the Survey Department as that devised by Colonel Everest. ... I...transmit herewith an extract from Part 2, vol. 7th., General Report, together with copies of the tables and forms. ... You will make your future calculations of latitude and longitude by the type...herewith furnished. ...
>
> I...call your attention to two irregularities...in the latitude and longitude sheets. ...
>
> 1st. The computations of several secondary points...are transcribed in pencil.
>
> 2nd. The sheets do not bear on each page the names of the persons by whom the computation has been performed. It is a rule...that these computations which are intended to be preserved among my office records should be at once written in ink with a clear and neat hand, and attested by the signatures of two computers[2].

He was always ready to assist his surveyors, especially whilst he had Radhanath Sickdhar at field headquarters, and writes to Walker on the Maluncha series ;

> We have no instance on record of a double hexagon, and consequently no example of a case precisely similar to yours. ... Perhaps, considering the quantity of other work you have on hand, both in the shape of computations and transcription of your angle-books, etc., besides the examination of your instruments and implements, it would be advisable for you to send the data of the double hexagon to me for computation. The computation will not take more than 10 days and, allowing 12 days for the post each way, the results...may be expected to reach you in 34 days after the despatch of the data from your office. ...
>
> You must take care that the angle-books have been duly examined before you extract the data from them, and the extracts must be duly attested, also the probabilities and spherical excesses, if the latter happen to have been computed. It would be a great waste of time to commence the tedious computation of a double polygon from wrong data[3].

Computation forms were lithographed at Calcutta under the direction of the Chief Computer, who in May 1853 submitted to the Deputy Surveyor General

> a form for the computation of azimuths from circumpolar star observations [for] ...having 150 copies lithographed, of which 40 are to be sent to Captain Strange at Karachi. ... This form is contained in 5 sheets of paper. ... The form was first tabulated by Captain Strange to suit his observations with the great theodolite, and he applied to have it lithographed on account of the great number of azimuth observations taken on the Great Longitudinal Series.
>
> It will also, in common with the other computation forms of the Department, facilitate the subsequent examination of the computations of field parties[4].

AUXILIARY TABLES

One of the greatest contributions which Radhanath Sickdhar made to the Great Trigonometrical Survey was the preparation and publication of a set of tables to be used with departmental formulæ and forms. In the course of its preparation he introduced all the changes approved by the Surveyor General, and in many ways reduced the labour of computation without loss of precision.

[1] Waugh MSS., II (iv). [2] DDn. 325 (171-3), SG. to Rivers, 22-10-44. [3] DDn. 512 (93), SG. to Walker, 6-7-46. [4] DDn. 569 (7), 19-5-53.

The first edition was entitled *Tables to facilitate the Computations of a Trigonometrical Survey and the Projection of Maps.* It was of octavo size, containing seventeen tables and four pages of specimen computations and printed at the Military Orphan Press, Calcutta, 1851; "computed and arranged by Babu Radhanath Sickdhar, Chief Computer".

Its preparation had been ordered by the Surveyor General to replace the map projection tables prepared by Valentine Blacker in 1825 [III, 293-4 ; IV, vi][1];

The British dominions in India having been extended beyond the parallel of 32°, which is the northern limit of Colonel Blacker's graticule, it has now become necessary to continue those projection tables to 36° or 37° of latitude, which is the farthest range to which our influence is likely to reach. ... It seems advisable to have these tables revised and extended. ... It may be worth while to lithograph them for general distribution. ...

I have a great respect for Colonel Blacker's memory, and would not lightly alter what he has settled, but...it appears...most convenient in practice to project the parallels and meridians to every ½-degree, to every degree, or to every 2°, according to the scale. ...

The first table should be a general one, giving the meridional and longitudinal degrees and their diagonals in...miles to 3 places of decimals. ... All the rest of the tables might be special ones, adapted to special scales, and shewing the lengths...in inches and decimals. ...

You will remind the Chief Computer that in consequence of the progress made in the N.W. Himalaya series [pls. 3, 5], we shall almost immediately require the additions beyond 32° of latitude to Colonel Everest's tables for computing terrestial latitudes, longitudes, and azimuths [IV, 433]. ... If copies of Vlacq's tables have arrived, Baboo Radanath may commence at once on this work, giving his earliest attention to the part beyond 32°. ... If the copies of Vlacq's work are not expected soon, it will be necessary to extend the latitude and longitude tables beyond 32° with the means we have, viz., 7 places of logarithms[2].

About a year later Radhanath was asked to get out "very urgent...a set of tables for facilitating computations. Those now in use are manuscript. A set should be prepared as soon as practicable and 100 lithographed copies taken for departmental use"[3]. He reported in December 1850 that

two computers were employed for about three hours daily from 1st July to the end of September upon the deduction of the Tables, and...since the 1st October they have devoted six hours every day to that work. ... Supposing that no more than two computers are employed...the completion...cannot be expected in less than three or four months[4].

He was allowed to employ the whole strength of the computing office on the work, and

in the year 1851 the printed tables...were computed. This work naturally divides itself into two parts; 1st, the investigation and the thorough understanding of the formulæ, ... and 2nd, the performance of the computations themselves. The first part...being very carefully gone over by me, the latter part...was entrusted to the computers. In making some of the computations Vega's and Vlacq's Logarithmic Tables to 10 decimals were used. ...

Although these Tables have been in constant use...for the last four or five years, not a single mistake...has been discovered, either in the computation or in the printing[5].

A second edition under the title of *Auxiliary Tables to facilitate the calculations of the Survey Department of India* was issued at Dehra Dūn in 1868, revised and extended by Hennessey, containing 26 tables and 19 pages. A third edition followed, also from Dehra Dūn, in 1887[6].

LOGARITHM TABLES

There were several logarithm tables in general use in the Great Trigonometrical Survey, and surveyors were free to use which they pleased. Hutton was an old favourite, followed by Babbage; there were as yet many errors to be found in Shortrede's tables. These were all seven-figured, and Vlacq's ten-figured tables were required for special work. Wroughton writes in February 1845 ;

Of the 3 logarithmic works (each 2 copies)...to be purchased, I have succeeded in procuring only one, viz., Hutton's Logarithmic Tables (Gregory's latest edition), 2 copies at Rs. 11-4

[1] GBO. Lib. H.q. 3 ; Litho, Calcutta, 1825. [2] DDn. 561 (49), SG. to DSG., 22-6-49. [3] ib. (108), 13-5-50. [4] DDn. 474 (438), 14-12-50. [5] DDn. 669 (13), to DSG., 3-4-56. [6] *SI Pubns.* (xxi).

each, from Messrs. Thacker & Co. The Logarithmic Tables by Babbage...are not to be had at present in Calcutta at any of the booksellers' shops. If indispensably required they must be obtained on indent from England direct.

By this day's bangy dak I have despatched...the two copies of Hutton's Tables ; ... no other copy even of this work is now procurable[1].

In 1849 the Surveyor General approved issue of Hutton's Tables for the G.T.S. and revenue surveys, and in 1852 nine copies of Shortrede's were ordered from England, the "revised edition, of which favourable mention is made in the 19th volume of the Memoirs of the Royal Astronomical Society [IV, 467]"[2]. He thought it desirable that the Computing Department and my field office should possess a copy of every edition of logarithm tables of superior pretension and extent, because the use of separate works is a check on tabular and typographical errors which lurk more or less in all books.

It is also desirable that each party...should have a sufficient variety. ... At present the only Tables containing the logs of trigonometrical sines to every second are Taylor's and Bagay's, the former of which is very costly and difficult to procure[3].

He later agreed with the Chief Computer's criticisms about Shortrede's Tables, being of the opinion that "a really good set of logarithm tables in all essential respects is still a desideratum".

In 1861 Robinson reported that his party held the following tables—Callet [III, 183]—Bagay [IV, 344]—Hutton, 2 copies—Taylor [IV, 467 n.2]—Shortrede, 2 copies. In 1862 the Surveyor General acknowledged a copy of Bagay's Tables ;

It contains some valuable astronomical tables, especially a table of atmospheric refractions, with corrections for the height of the barometer and thermometer, which latter was particularly required for the observatory...in calculating the exact time of sunset. These tables are not given in Shortrede, and hence the necessity for Bagay was more particularly felt[4].

INITIAL ELEMENTS

For his final computations of the Great Arc Everest adopted Kaliānpur, near Sironj, as his point of departure in latitude, longitude, and azimuth. The longitude 77° 41′ 44″ had been brought up from Madras Observatory for which the value determined by Warren in 1807 was 80° 17′ 21″ east of Greenwich [II, 195]. The latitude was taken from Everest's 388 observations of 1825, giving value 24° 7′ 11″·837. He disregarded 3,340 observations taken between 1839 and 1841 because he doubted the catalogue places. By the Greenwich catalogue published just before 1847, however, he made the latitude of Kaliānpur from all observations to be 24° 7′ 11″·26, and this was later accepted by Waugh [IV, 103–4][5].

The fundamental azimuth for the northern section of the Great Arc was that observed by Everest at Kaliānpur in 1825. Lengths of sides were derived by adjustment between the base-lines measured at Sironj and Dehra Dūn.

The height of Kaliānpur was taken as 1878·2, being derived from Lambton's height for Damargida, 2,026 feet [66].

Computations were based on the figure of the earth defined by Everest's Constants, 1st set, published in 1830 [III, 253–4]—Semi-major axis (*a*), 20,92,29·31 feet—Semi-minor axis, 20,853,374·58 feet—ellipticity, 1 : 300·80[6]. These constants are still used in the Department for mapping purposes.

In his instructions for the North-West Himālaya series, running west from the Amsōt–Banog side of the Great Arc, Waugh ruled that the series would depend on the measured value of the Debra Dūn base-line. As regards azimuth,

on account of the great local disturbance in the direction of gravity at all the stations of the N.W. Longitudinal series, the azimuth cannot be satisfactorily determined on the spot. This element must...brought up from a distance, and will depend on its observed value at some station of the Great Arc, remote from the influence of mountain attraction [133–4].

The observations at Kalianpur...appear to be free from any suspicion. ... There is every reason to conclude that the computed azimuth at Kaliana as brought up from Kalianpur is

[1] DDn. 458 (63), DSG. to SG., 11–2–45. [2] DDn. 555 (12), DSG. to Thacker Spink, 24–4–52. [3] DDn. 580 (18), SG. to DSG., 2–9–52. [4] DDn. 27 (176), SG. to DSG., 19–8–62. [5] *Mer dl. Arc.* (clxxii–iv); *GTS.*, II (133–41). [6] Geo. Everest (115) ; De Graaff Hunter, *Geod R.* IV, 1927–8 (1–3).

true within a second. ... The retention of the old azimuth will make the new operation harmonious with those of the Great Arc.

The observed latitude of Kaliana is unquestionably affected to a considerable extent by mountain attraction. ... The proper origin for upper India is undoubtedly Kalianpur, a locality which there is every reason to consider free from irregular attraction, and the position of which has been fixed by no less than 3728 accordant observations; ... mean by 3 observers and 3 instruments, 24° 7′ 11″·26. This position differs 0″·6 from the former value, ... a correction applicable to all latitudes of the Great Arc, as well as all latitudes to the eastward.

Waugh notes that Everest's 2nd Constants [IV, 104], deduced from the final results of the Great Arc, were not used because the final values were still uncertain;

1st. The new Indian arcs remain in terms of Standard A. Now, as Prof. Struve[1] is at present engaged in a comparison of all the standards used in these trigonometrical operations, the result of his researches is likely to produce some alterations in the value of the constants deduced by Colonel Everest. ...

It appears to me advisable...to retain the old values...until...a revision of the Standard, and the introduction of all the new continental operations, as well as the new survey of England. Any change which we make should be final, more especially as the extension of our old values is supported by the authority of Prof. Airy and Prof. Bessell, whose determinations are... accepted in England and on the continent, with which our old values agree very closely[2].

When the final reduction of the whole trigonometrical system was made some years later, General Walker made no change from the constants used, but noted the redetermination by Colonel Clarke of the Ordnance Survey of Great Britain, who had "employed in his investigation a large amount of provisional data, including longitudinal as well as meridional arcs, from the latest operations of this survey". Walker, however, revised the value of the fundamental azimuth at Kaliānpur, taking account of local attraction,

to bring it into closer accordance with the observed azimuths at fifty-one stations symmetrically situated around it, at various distances, on the contiguous chains of triangulation. The corrected value of the azimuth may be accepted as a more reliable initial element than the original value, and better adapted for general application than the local determination [133][3].

GEOGRAPHICAL POSITIONS

Everest had published his first official lists of geographical coordinates in 1842, having been compelled, under pressure from the Court of Directors, to speed up his calculations without completing the final adjustments [IV, 101–2]. In 1844 Waugh sent the Quartermaster General

3 copies of the List of Latitudes and Longitudes determined by the Great Indian Arc and the Amua Meridional series, and printed by the orders of Government. ... The results of the Budhon, Ranghir, Himalaya, and Pilibhit series are ready for publication, and will be forwarded when printed. It is my intention to rearrange the whole of these geographical data under the heads of Provinces and Districts, which...will render them more convenient[4].

In sending out a later list he notes that

in making use of the latitudes and longitudes...it is proper to employ as data for the construction of your map the figure and dimensions of the Globe as determined by these operations. These are fundamental elements of Indian geography. ...

I have forwarded a lithographed paper containing instructions for describing the graticule, on any required scale, for maps not exceeding 100 superficial degrees. By means of these tables such maps may be constructed with great facility and despatch. ... Trigonometrical operations have not been extended further west than Delhi and Karnal, beyond which our geographical knowledge is at present limited to the Revenue measurements and other minor surveys. ...

To facilitate the use of the lists of latitudes and longitudes I have sent a sketch map shewing the principal stations and directions of the several series[5].

In 1849 he issued a new note regarding the longitude of Madras;

The latitudes of the Trigonometrical Survey are...final, but the longitudes are referable to the old value of the longitude of Madras as an origin. This should be noted as a remark

[1] Freidrich Geo. Wm. Struve (1793–64); German Astr.; Dir. Pulkowa Obsy., St. Petersburg 1839–61.
[2] DDn. 466 (101–7), Note by SG., 1848. [3] *GTS.*, II, pref. (xiii–xiv). [4] DDn. 453 (175–6), 5–8–44.
[5] ib. (285–6), Aug. 1845.

on all maps issued wherein the meridian lines correspond with the origin of the G.T. Survey, so that the Hon'ble H.E.I. Company's Hydrographer may not be misled.

The old and new values of the longitude of Madras Observatory will be furnished by the Chief Computer. ... It was decided by my predecessor that no alteration should be made in the trigonometrical records on account of the change in the deduced longitude of Madras Observatory in order to prevent confusion, to maintain uniformity throughout, and because the real value...is...not finally settled [IV, 103-4 ; V, 313][1].

In spite of this order the Agra-Bombay road map issued in 1852 had the western portion plotted on one value of the Madras longitude, and the eastern portion on the other [IV, 269-70 ; V, 309] ;

It signifies little comparatively whether India is 3½ miles nearer or further from England, but it is a serious matter whether places near each other in India are represented on the maps erroneously by no less a quantity than 3½ miles. ... I see no alternative but to recompile the Agra & Bombay Road Map, and suppressing entirely the present edition[2].

FIELD PARTIES

Besides keeping up computations both in field and recess, surveyors had to submit monthly progress reports ; "to enable the Surveyor General to exercise an effectual control over the execution, progress, and computation of the several series"[3]. They were encouraged to look to the Chief Computer for assistance, and Armstrong, from the Hurilaong series, asked his advice about

the transit observations made at Hurilaon, and...your selection of such of them as will determine the correct time and rate of the chronometer. ... Kindly determine for me the error and rate of the chronometer, for I have no Ephemeris with me to do it, and I am far from an experienced hand in such computations, having no old forms to refer to. ...

Indeed, I would be particularly thankful if you could send me a copy of all the computations which occur in the deduction of azimuths, something like the one I used to see Sreenath refer to when he and I were computing together at Digah Castle [17, 368 n.3]. I will of course return the copy. ... but I shall take good care that I possess a similar copy for...future occasions. ...

Somehow I have hitherto depended more upon my recollection of computations than on prescribed examples, and hence my dilemma when forced to depend upon my own resources.

Don't think me a troublesome fellow, Radanath, for in the end you will have less trouble with my series than otherwise. ... I am determined upon bringing up my Report fairly—so fairly indeed that you will not have the task of recomputing any portion...if I can help it[4].

Armstrong had later to explain why he had omitted to fix the position of two important towns on the Gora series [118] ;

These were laid down by direct triangulation, ... and...when the Chendwar and Gora... parties were cantoned at Allahabad in 1848 a packet containing these...[was] forwarded to Mr. Logan for computation by such of the assistants as could be available. ...

I took charge of the books, but unfortunately we have never had a spare moment since then and—immersed as we have been in the computations of the Hurilaong series for the past two seasons—the books have lain...altogether forgotten. ... The books...are four in number, and...are by far the most valuable records of the secondary operations of the Gora series. ...

My attention was undividedly devoted to the immediate computations of the season's work. ... Indeed, with the exception of the few hours devoted to the necessities of life, every hour...was given...to this duty, and it was...a difficult task...to compete with two parties so computing, and at the same time to attend to the miscellaneous duties of the office[5].

Errors were found in the work of so experienced a computor as John Peyton, who had at one time been Radhanath's teacher ;

The vigilance of the Chief Computer having detected no less than 11 errors in the zero means of the principal angles of the Calcutta Meridional series as deduced by the Surveyor, the attention of officers in charge...is earnestly called to the necessity for rigorously checking their angle-books. The accuracy of the whole work depends on the angles being correctly deduced from the observations, and this is the first and most important duty of the heads of parties, who are strictly responsible for all errors[6].

[1] DDn. 561 (66), SG. to DSG., 28-5-49. [2] ib. (257), SG. to DSG., 23-8-52. [3] DDn. 455 (4-5), DO., 8-1-44. [4] DDn. 568 (1), 26-6-49. [5] DDn. 557 (86), Armstrong to SG., 12-1-51. [6] DDn. 566 (9), DO., 20-11-51.

The party computations were sometimes accepted for incorporation in the final record volume. The Surveyor General sent to Peyton on the Coast series

two sets of forms which have been carefully prepared by Captain Renny-Tailyour, Astronomical Assistant. ... One set contains the forms for field computations, and the other contains instructions and forms for preparing the General Report in a shape fit for publication. The field computations...being conducted in duplicate by two computers, ... these documents when bound together will form two authentic volumes of field records from which a fair copy of the General Report can be prepared. ... In the event of the fair copy...being lost or injured in transit, the computation records will supply the means of preparing another copy. ...

As your field season on the Coast series is barely three months in duration, you will have nine months per annum of regular office duties, and, therefore, will be able to prepare the General Report of your series in a final and authentic shape. ... To render your materials available for geographical compilations in my office, a fair chart with lists of latitudes and longitudes and heights of each season's work is required, to be sent in every year [120–1][1].

A departmental order was issued on the subject during 1854 ;

Progress...has not corresponded with the field work. ... Many of the computations occupy more time than the field work. One source of delay...arises from the necessity of completing each series before the final verifications are arrived at. The corrections derived from these verifications, though small, necessitate more or less a general revision. As the chief value of the results consists in the perfection of accuracy, much caution is required in every step of the computations, all of which require verification by two computers, and rigorous comparisons. ... The preparation of the final report must, therefore, ... prove a tedious labour. ...

" The number of maps now compiled in my office...create a corresponding demand for trigonometrical results. ... This object, in the case of recent operations in the Punjab, has been accomplished by the preparation, season by season, of a final plan, with a list of numerical values in latitude and longitude, most useful for compilation purposes. ...

Officers in charge of series are, therefore, ordered to furnish, season by season, a carefully projected chart on the scale of 4 miles to an inch with the numerical values engrossed thereon. ... No chart without numerical values...can be reckoned more than a sketch, because the paper is liable to alteration. It is better to record the numerical results on the chart than to give them in the form of a list, as it prevents separation and accident [120–1][2].

COMPUTATION RECORDS & REPORTS

The greatest care was devoted to the preparation of the manuscript General Report of each series of triangles. The original was kept in the Calcutta computing office, the first copy being sent to India House in London, and the second to the Surveyor General's field office[3]. At the end of his first year as Surveyor General Waugh informed Government that

greater progress would have been made in these extensive computations had it not been necessary to employ a large proportion of my computing office in preparing duplicate copies of the Great Arc angle-books, and triplicates of the 7th, 8th, and 9th volumes of the General Report [IV, 110–2]. I have been obliged to leave Mr. De Penning and a portion of the office in Calcutta for the sole purpose of preparing these transcripts because, until duplicates have been made, it would be imprudent to transmit the original angle-books to the India House.

The triplicates of the General Report are required for the use of my office in the field. Very slow progress can be made by four computers in transcribing these voluminous documents[4].

In addition to making these copies, the Calcutta office was employed on the recalculation of the triangulation of all the Madras topographical parties from 1816. On taking over as Deputy Surveyor General Thuillier found

two of the computers...making duplicates of the Calcutta Longitudinal...and Parasnath series angle-books, and the other two comparing the Great Arc...angle-books. ... The first comparison of the 10 volumes of the Great Arc...was completed in that month [July 1847], when by the direction of the Chief Computer (temporarily present at the Presidency on sick leave) [341]...a *second* comparison was instituted. ... This comparison is still in progress [Dec. 1848][5].

Field work was now progressing rapidly, whilst computations were lagging. "The labours of those in Calcutta have declined...[for] want of adequate

[1] DDn. 600 (28), 1-10-53. [2] DDn. 455 (210–2), DO., 1–6–54. [3] MS. Reports, *IO Cat.* (3-24). DDn. 414 (96–7), SG. to Mil. Dept., 6–1–45. [4] DDn. 472 (711–4), DSG. to SG., 4–12–48.

supervision. ... A change...becomes necessary"[1] [341, 354–5]. It was decided to concentrate the computing office at Calcutta under the Chief Computer, and Radhanath took personal charge at Calcutta in May 1849, charged with early completion of

the General Report of the Gurwani Meridional series. ... The chart is now under compilation at my field office, and will serve as a model for that part. ... I have directed him to examine the transcripts of the Great Arc angle-books. ... The final completion and despatch of these books to the India House is a matter of urgent importance. ... As soon as computers become available...I have directed the General Reports to be taken up in order—The Gora Meridional. ... The Maluncha Meridionals. ... The Bombay operations—The Calcutta Meridional, ... the Chendwar, ... and North-East Longitudinal...I propose to undertake myself[2].

By 1854 the Surveyor General had a small computing office working at his field headquarters at Dehra Dūn under Hennessey, which by 1856 had completed General Reports for part of the Hurilaong Meridional and NE. Longitudinal series, including computation of the snow peak observations [90–2, 343].

In 1856 the Chief Computer submitted a report showing all the work completed at Calcutta from May 1849 to April 1856. His staff had consisted of himself, a Head, and a Deputy, Computer, and six assistant computers;

The Reports which have been brought up are...Gurwani, ... Gora, Calcutta Meridional. ...

Altho' the bringing up of the Report of a trigonometrical operation is always a very laborious occupation, the...Calcutta series report has proved particularly so. ... The computers only assumed that the Surveyors have correctly recorded their observations in the angle-books. ...

Commencing from this point, they went over very carefully all the details of computation, and arranged and digested the results; also, when required, verified those results by independent processes of computation. ... Laborious calculations...and the continued watchfulness... to guard against errors...were both very great. ...

The Reports...now on hand are...Maluncha series...Chendwar...Hurilaong[3].

Previous to my leaving Dehra Dhoon in 1849 some mistakes were discovered...in the computation of the meridional triangles of the Great Arc. ... It was the wish to the Surveyor General that as soon as I reached Calcutta I should have the whole of this calculation revised.

Other work had been the preparation of tables for the Auxiliary Tables, and the testing and preparation of formulæ and tables for the computation of polygonal figures [123, *inf*][4]. A very important part of each General Report was the final chart of the series, which was prepared on the same lines as the preliminary chart submitted at the close of each field season [120–1, 127].

DISPERSAL OF ERRORS

In January 1851 the Surveyor General called on the Chief Computer to try out a new method devised by Gauss for the dispersal of triangular errors through composite polygons and quadrilaterals, which promised better results than the method followed by Everest. Radhanath first tried two simple figures by this new method, and obtained results closely agreeing with the old method. He then took up

the seven quadrilaterals formed on and about the Seronj base. These...form the most complicated figure that occurs in the Trigonometrical Survey. They produced no less than 46 equations, some of which were of very unwieldy magnitude. ... The solution...occupied four computers seven months. ... The results...were highly satisfactory, shewing that the greatest discrepancy...between Gauss's and Col. Everest's methods...would not exceed 0".14[5].

Waugh concluded that the new method was too laborious for departmental use.

A more serious matter was the recomputation of the Calcutta Longitudinal series, to determine the best values for the points of departure for each of the subordinate meridional series, and the distribution of the errors found on closing with the North-East Longitudinal.

Since the year 1834 new azimuths have been observed at the several stations of the longitudinal series...which have been used as the origins of the meridional operations. These

[1] DDn. 462 (234–6), SG. to Mil. Dept., 13-11-48. [2] DDn. 561 (12), SG. to DSG., 13-3-49. [3] Reports, Hurilaong, Chendwar, N. Parasnath, completed by Radhanath before rett., 1862. [4] DDn. 669 (13), Ch. Compr. to DSG., 3-4-56. [5] DDn. 562 (109), Ch. Compr. to SG., 19-7-51; 561 (187), SG. to Ch. Compr., 3-9-51; 669 (13), Ch. Compr. to DSG., 5-4-56.

azimuths differed from those taken by Mr. Olliver prior to 1834 by from 15 to 22 seconds, and as they have been undoubtedly observed with better instruments, and according to a better system, ... those elements should be taken advantage of[1].

The recalculation of the longitudinal series was taken in hand in September 1853 and completed in five months. It was entirely re-observed from Sironj to Calcutta between 1863 and 1868.

The final distribution of errors and reduction of results of the triangulation of the Great Trigonometrical Survey was carried out under the direction of General James Walker whilst he was Superintendent of the Trigonometrical Survey and involved some twenty years of hard and sustained work. The whole triangulation was divided into five figures—North-West [pl. 5], North-East [pl. 4], South-West, South-East Quadrilaterals—and the Southern Trigon. The final computations, with brief historical accounts, were published in a series of volumes entitled *Account of the Operations of the Great Trigonometrical Survey of India*;

The first volume published Dehra Dūn 1870, described the Standards of Measure and the Base-lines, and included an account of the early operations.

Volume II, published 1879, gave a History and General Description of the Principal Triangulation and of its Reduction.

Volumes III, 1873—IV, 1876—and IV A, 1886, covered the North-West Quadrilateral.

Volume VI, 1880, the South-East Quadrilateral.

Volumes VII and VIII, 1882, the North-East Quadrilateral.

A series of *Synoptical Volumes* was also published, taking each triangulation series separately, and giving the essential results, with charts and historical summaries. Of these Vols. I, II, and III—covering the Great Indus series, the northern section of the Great Arc, and the Great, or Karachi, Longitudinal series—appeared in 1874, whilst Vol. XXXV, covering the North-East Longitudinal series did not appear until 1909.

[1] SG.'s memo. June 1853 DDn. 594 (425); Waugh MSS., II (pp. iii, 22).

CHAPTER X

ASTRONOMICAL & OTHER SCIENTIFIC WORK

Astronomical Observations — Azimuths — Himālayan Attraction — Departmental Observatories — Meteorology — Electric Telegraph — Photography — Geology — The Schlagintweit Brothers.

UNDER Waugh's direction regular astronomical observations for azimuth and meridian were continued along both meridional and longitudinal chains of triangles as check against accumulation of error in direction ;

When trigonometrical operations are carried on in a single series composed of a succession of simple triangles, the symmetry of those figures and the minuteness of the triangular errors do not afford sufficient guarantee that the work will prove satisfactory on verification.

It is therefore necessary...that azimuth observations should be taken at stated intervals apart, whereby it may be ascertained by an independent process whether the angular errors are properly compensating each other, or are unduly combining [IV, 101 ; V, 204, 286][1].

Garforth was told to make frequent observations whilst in recess at Allahābād ;

Expertness can only be acquired by constant practice. ... In conformity with the standing rules...you will commence a systematic course of observations, ... a set every evening, Sunday excepted, on Ursa Minoris at its eastern elongation...with the usual transits for time[2].

Astronomical observations for zenith distance, or latitude, had been made by Everest along the Great Arc for determining elements of the figure of the earth [IV, 16, 96–101]. Waugh was later anxious to have the accuracy of the longitudinal series from Sironj tested by observation of latitude at Karāchi, as thus explained by Strange ;

The series which I have just completed is the largest arc of parallel ever yet measured in any part of the Globe under favourable circumstances and with first-class instrumental means. ... The computation of this arc has been conducted with an assumed value for the figure of the Earth. This value has been found adequate to the requirements of meridional arcs, but has never, until now, been tested fairly on arcs of parallel.'

The Surveyor General observes that one effect of an insufficiency in our formulæ will be to vitiate the latitude of the termination of the series, and that it is therefore desirable that I should determine that latitude astronomically. He considers that until this test has been applied it would be imprudent to issue data...for geographical purposes...as to the latitudes and longitudes. He has accordingly instructed me to determine this element with all the accuracy possible, a task which will involve about 300 delicate astronomical observations[3].

After preliminary observations by Strange in 1853, the main observations were entrusted to Tennant who constructed an observatory on Bath Island, "situated between Kurrachee and Clifton", on the condition that "the privilege of bathing at this island, hitherto allowed to European soldiers, is not to be withdrawn"[4]. One of Everest's astronomical circles [IV, 131–5] with an astronomical clock was put in order and erected with the help of Mohsin Husain. The observations were carried out during March and April 1855 [44, 46] ;

On the morning of Easter Sunday the 8th April...heavy rain came on, and the roof of the observatory leaked. This was remedied by spraying the joint where the wood joined the tiles with tar and then nailing over a flap of the tarpaulin. Since this, though rain has again been falling, the roof has been dry. Clouds and rain delayed the completion of the observations till the 25th April ; ... connection by three single triangles...computed since[5].

Tennant made 1614 single observations, and deduced a value of latitude only 0″·882 less than the value brought up by triangulation from Kalianpur[6]. The

[1] DDn. 325 (377–83) 1, ol. 27–8–45. [2] DDn. 723 (13), 12–9–45. [3] DDn. 618, Strange to Comnr. Sind ; 1–8–53. [4] DDn. 621 (266), Collr. to Tennant, 22–9–54. [5] DDn. 593 (629), Tennant to SG., 25–5–55. [6] *GTS*, XI (1—10).

observatory was then closed, and the marks carefully covered and handed over to local officers for preservation [113]. The astronomical circle was sent up by steamer to Sukkur, and at the close of the field season accompanied Tennant's camp to Dehra Dūn. Tennant reports before leaving Karāchi that

the astronomical circle and clock have been carefully packed and placed in the observatory ready for removal. The clock had remained standing for the azimuthal observations, and the sea air had much rusted all but the parts subject to friction. I have...had to clean the whole and have again oiled it. ... The iron limb of the astronomical circle I have...covered with lard[1].

His report appears amongst Waugh's MSS. and an abstract was published by the Royal Astronomical Society[2].

Officers were encouraged to observe occasional latitudes on each series of triangles and, writes Waugh to Peyton on the Calcutta Meridional series,

this would not only afford good practice...to yourself and sub-assistants, but would also be interesting in a geographical point of view as affording the means of comparison with our trigonometrical operations. The only instrument available for your purpose is the vertical circle of Troughton's 18-inch theodolite [148, 155]. Altho' it is inferior in power and division of the limb, ... it would in 4 or 5 nights determine the latitude to about 1″ of the truth[3].

Waugh set little store on astronomical observations as substitute for triangulation [III, 175–92] and questioned the need for keeping sextants and

artificial horizons. ... These are navigation instruments and, as the first wave of geographical discovery in India partook...of the character of inland navigation, astronomical instruments were necessary, and corresponding observations were taken at the Surveyor General's Office. ... The astronomical observations of those days were works of high merit, far beyond the reach of a sextant and artificial horizon. But no astronomical observations, even with the highest order of instruments, can compete with terrestial measurement. ... No revenue survey should ...correct itself by astronomical measurements, as they are decidedly inferior.

I have a...horror of astronomical surveying. A good surveyor should have firm faith in the accuracy of his own measurements. If latitudes and longitudes are wanted, those of the trigonometrical survey are...strictly correct as to relative positions. Let the revenue surveys ...base upon these points, with which no astronomical measurements can pretend to compete.

If a Revenue Survey precedes the Trigonometrical, let one point of departure be fixed astronomically by good instruments sent temporarily from the office. ... The astronomical part of the work should be considered merely temporary, to be replaced afterwards by the values given by the Trigonometrical Survey [119][4].

Thuillier insisted, however, that the revenue surveyors should observe astronomical azimuths at all their control points, and in the Punjab a small detachment was employed to construct masonry pillars at circuit junctions for that purpose;

The sextant and artificial horizon...have been invariably attached to every Revenue Survey from the commencement, ... more, I imagine, for the purpose of correctly finding the true azimuth. ... Unless theodolites with vertical arcs of 40° or the full circle are supplied...it seems ...inadvisable to dispense with the sextant [298][5].

ASTRONOMICAL AZIMUTHS

It was a standing order that astronomical azimuths should be observed at the starting and closing stations of every chain of triangles, and also "at moderate intervals along the series" [IV, 95–6];

In a meridional series the azimuth stations should be as near the meridian, and in a longitudinal series as near the parallel, as possible. ... The fundamental azimuth...taken at the station of origin must always be observed to a Nautical Almanac star at its periodic time. ... In these days of astronomical improvement the places of the stars given in the Nautical Almanac may be relied on with great confidence, and no other stars should be employed in the case of single elongations[6].

Observations were taken to circumpolar stars, and every effort was to be made "to observe the same star at both elongations". A set of azimuths consisted of

[1] DDn. 592 (346), SG. to Tennant, 1–11–55; 621 (397), Tennant to SG., 2–11–55. [2] Waugh MSS., II(a) & *RAS.* (*mn*) XVII, 1856-7 (56–8). [3] DDn. 573 (32), 29–8–45. [4] DDn. 473 (89–96), SG. to DSG., 28–12–48. [5] DDn. 474 (16–21), DSG. to SG., Jan. 1849. [6] DDn. 515 (296), CL., 27–8–45.

at least 8 observations at each elongation, four before and four after. "Eight observations can easily be taken without hurry or confusion" in a space of 40 minutes, but in some cases the requisite number of sets on prescribed zeros might extend over one or two weeks[1]. To Nicolson starting the Assam longitudinal series the Surveyor General writes ;

Eastern Bengal is unfavourable for such observations on account of fogs and clouds which are even more detrimental to astronomical observations than to the terrestial work. ... You will meet frequent disappointments, and care must be taken not to waste time in uselessly waiting for clear weather. If the weather is clear when you arrive at a station...you can take them, otherwise pass on and endeavour to arrange for taking them at a more favourable epoch. ... Observations...on 7 zeros would occupy no less than 7 days, which is a serious interruption to progress. Captain Strange has found it practicable to change zero during the observations, thus accomplishing 2 zeros in 24 hours[2].

To Strange on the Coast Series he writes ;

Considering the limited field season...I think it will be sufficient to observe at convenient stations about 70 to 100 miles apart. As you go south you will find these observations become more difficult from longer daylight and the diminishing elevation of the pole[3].

To Logan on the North-East Longitudinal ;

As a general principle...it is very desirable that azimuth of verification should always be observed at the point where two series...unite, and more especially if these...have been executed by different parties, because if a disagreement exists...the azimuth observations will shew in what proportion the error is to be distributed. ... It is desirable that all series in the plains should be checked at every 50 miles. ...

Azimuths near the hills are liable to disturbance, but at the distance of the Longitudinal Connecting series the disturbance must be small, and likely to be the same at each place of verification. ... We can know nothing, either, regarding the disturbing force on the correctness of the triangulation unless azimuths of verification are observed. ... The apprehension of mountain attraction is no just reason for omitting such observations[4] [98, 133].

He particularly desired Logan to observe at Bela "because of the great errors of the Karara Series" ; these errors had been shown up when he had himself observed at the junction of the north and south sections in 1845 [II, 114–5, 156].

The Great Longitudinal series was of high importance, and indeed the inadequacy of the controlling azimuths had been a serious blot on the Calcutta section [IV, 58, 95]. In his instructions to Renny the Surveyor General writes [38, 98] ;

Colonel Everest's azimuth observations at Kalianpur, together with the new latitude and the old longitude of that point...will form the fundamental elements for the origin of your work. ... I would advise you to observe azimuths at every alternate station if the sides are long, or at every degree...if the sides are short, selecting...such stations...as may appear to be most free from...lateral attraction on the plumbline...at right angles to the meridian. ...

In some cases it would be interesting to measure the amount of attraction. For example, observations to the east and west, and on the summit, of Aboo would be interesting[5]

The disturbing effect of the mountains was specially noted along the North-West Himālaya series, the Surveyor General writing to Walker at Jogi-Tila ;

In consequence of the Himalayan attraction no confidence can be placed the direction of the plumbline in the vicinity of these stupendous mountains. This attraction is chiefly north-easterly, and vitiates...all results of astronomical observations depending on a true level. ... For this reason it has been impracticable to obtain trustworthy azimuths or latitudes of the North-West Himalaya series. ... The greatest apparent deflection which has been detected amounts to 37″·7 in latitude, and in azimuth 20″·156 [III, 35, 177 ; V, 134][6].

If an erroneous azimuth be adopted at the origin of your series, it would vitiate...your results. ... The probable deflection at Jogi-Tila may be...very much less. ... It will continue to decrease as you go south, ... perhaps...disappearing altogether at 150 miles, although meridional effect may continue...for 100 miles further on. ...

It would tend very much to throw light on the subject of mountain attraction if satisfactory observations were made for latitude at the same stations as for azimuth[7] [135]. These observations...would...interrupt your progress materially. ... I would therefore recommend your confining the latitude observations to the smallest number of stations sufficient

[1] DDn. 325 (371–5), CL., 1-9-45. [2] DDn. 591 (203), 21-7-52. [3] DDn. 592 (375), instns. of 1-12-55 ; 82 paras. [4] DDn. 496 (227), 3-11-48. [5] DDn. 616 (8), 16-9-48. [6] *Merdl. Arc* (xliii).
[7] so-called "La Place" stations of later terminology.

to verify your latitude. ... I think it will be sufficient if you determine the latitude at Murree during next recess, also at the last station of...azimuth at which the non-meridional attraction disappears, and at another azimuth station, say 50 miles further south[1].

Walker and Basevi observed latitude at Murree during 1858, the observatory forming a triangle with two stations of the North-West Himālaya series; "I was fortunate in having a memorandum of the observations taken by Captain Renny-Tailyour in determining the latitudes of Dehra and Banog" [136–8][2].

Deflection of the plumbline was further considered in relation to azimuth observations along the Great Indus series;

The westerly attraction of the Belochistan and Soliman ranges may be expected to have some disturbing influence on the plumbline. ... The circumstance ought to be considered in choosing stations for observing azimuth, as well as in judging of the results, ... but I do not think it would justify the omission of circumpolar observations [132]. ...

Without such observations we should be entirely in the dark, both as regards the angular errors accumulated...and the probable amount and direction of the mountain attraction. ...

The stations...may be placed...100 miles [apart], more or less[3].

Little use was made of all these azimuth observations in the final reduction, as is explained in the following note by General Walker under whose direction that great work was carried out [125, 129];

The numerous astronomical determinations of azimuth, latitude, and differential longitude, which have been made at various stations of the survey, furnish a number of external and independent facts...with which the triangulation might have been brought into accordance. The azimuths ... seemed to have a claim for introduction, as they were measured with the intention of forming a check on the triangulation. They are very numerous.

But the triangulation of this survey cannot be forced into accordance with any astronomically determined facts of observation without a liability to introduce errors arising from deflections of the plumbline in astronomical observations, which far exceed the errors ordinarily generated in the triangulation. ...

Other errors would arise, more minute, but...very sensible in long distances, from the errors in the numerous elements of the Earth's figure. ... If the triangulation were to be forced into accordance with the astronomical determinations, it would become seriously distorted in parts, and unfitted for employment in further investigations of the figure of the Earth. ...

Thus in the final reduction...the only astronomically determined elements employed... [were] those which were adopted for Kalianpur, the station of origin of the calculations[4].

HIMĀLAYAN ATTRACTION

Both Lambton and Everest had been well aware that their observations were influenced by visible mountain masses and even by unseen subterranean variations of density [II, 261 ; III, 253–4]. Everest had noted the large deflections at Banog and other sub-himālayan stations, and had purposely selected Kaliāna at the northern end of his arc on account of its distance from the mountains [IV, 104–5].

Waugh, of course, knew all that Everest had noted on the subject, and fresh evidence accumulated as surveys progressed. He was, moreover, compelled to take more serious notice by the eagerness with which Shortrede pressed the matter after his resignation from the Survey. Shortrede wrote direct to the Government of India describing a series of observations he had taken in 1841 for the latitude of Dehra and his deductions that would, he thought, impugn the accuracy of Everest's northward closing of the Great Arc. The final account of that great work had not yet been published, though Waugh had manuscript drafts[5]. Shortrede writes;

I have long been of opinion that the mass of the Himalaya would have a sensible effect in deflecting the plumbline throughout northern India, but it was not till September 1841... that I had an opportunity of putting this idea to the test. ... The place of observation at Derah was about 100 feet west from the chimney of the Surveyor General's office, the position of which is fixed from the Great Arc [IV, 105, 166 ; V, 138]. ...

[1] *GTS*. IV & *Syn*. VI (V–VI—G). [2] DDn. Comp. M-9/7 ; Walker to SG., 13–9–59. [3] DDn. 711 (70), SG. to Walker, 24–11–58. [4] *Phil. Trans.*, 1895 ; *India's Contribution to Geodesy* ; JTW. [5] *Mcrdl. Arc*, pub. 1847 [IV, xvii, 113].

The latitude of Kalianpur, on which that of all the other points depends, was determined by observation to be 24° 07′ 11″·85 [IV, 104 ; V, 124]. ... The triangulation gives the latitude of Banog...30° 29′ 37″·51, and that of Derah, 30° 19′ 59″·98, exceeding the observed latitude 30° 19′ 22″·61 by 37″·37 [132]. This discrepancy is so vastly beyond every other known instance in any part of the world that it will certainly attract attention.

At Kaliana, where the Great Arc is made to terminate, the difference between the latitude by the triangulation and that deduced by amplitude from Kalianpur is 6″·4274. This —however it may be glossed over—is plainly only a part of what is due to the attraction of the Himalayas. ... Colonel Everest used to say that this discrepancy was very strange, and that he could not account for it, but I apprehend it is...sufficiently accounted for by the mass of mountains to the eastward. ...

I was curious to know why...Kaliana had been adopted for the end of the Arc, and on one occasion I asked Colonel Everest, who told me that it was...to avoid the attraction of the Himalayas. ... I remarked that...the only part of the force which...becomes nothing is that affecting the absolute force of gravity, whereas the other part affecting the level, or plumb-line, is then at its maximum.

He tried to show me that I was in a mistake. ... On this I referred to the spheroidal figure of the earth, ... showing that the equatorial protuberance, though always below the horizon, sensibly deflected the plumbline at every point on the surface. This could not be denied, and the subject was then dropped and never again referred to between us[1]. ...

I think I can...shew that the attraction of the Himalayas had diminished the observed latitude of Kaliana by more than 10 seconds, and that the work as it stands is unfit to be used for determining the figure of the earth. ... Having at length got leisure to reduce my observations, I feel it...due to myself...to bring the subject to the notice of Government[2].

The letter was passed to Waugh for comment, and he showed that Shortrede had produced nothing that was not already known ;

The existence of lateral attraction at Kaliana is by no means a new discovery. ... Colonel Everest's observations of Kaliana were taken in 1839-40, long prior to those of Captain Shortrede, and as soon as they were reduced and computed the result became known to every member of the Department, including Captain Shortrede himself. So far from that result being glossed over, it was...officially reported to Government. ...

Captain Shortrede's observations throw no new light whatever on this subject. ... Colonel Everest...had previously deduced a discrepancy of 6″·4 for the station of Kaliana and, as the great mass of mountains lies about 40 miles north of Dehra [in defect 37″·4], and nearly 97 miles north of Kaliana, these two discrepancies agree in fact very closely, being very nearly in the inverse ratio of the squares of the distances. ... The latitude of Belville as observed by General Hodgson and Captain Herbert...was...found to differ 14″·6 from the trigonometrical computation [III, 37 n.6], and as the distance of Belville from the attracting mass is very nearly 71 miles, this result also agrees within about 2½ seconds.

Waugh further pointed out that the instrument with which Shortrede took his much-vaunted observations, was that to which he later attributed "the badness of his observations on the Karara series" [155] ;

The influence of the Himalayan attraction is...clearly set forth in the General Report,[3] and its probable amount at Kaliana can be far more accurately estimated from Colonel Everest's own observations taken on the spot than from those of Captain Shortrede. ...

I...draw particular attention to Colonel Everest's remarks with reference to the azimuth observations at Banog, ... taken for the express purpose of ascertaining the probable effect of the lateral attraction exerted by the mountains in its vicinity [IV, 98, 104]. ... The observations at Banog were taken in September 1837, partly by Col. Everest, and partly by myself [IV, 41]. ... Before we ascended the hill we fully anticipated that the immense disturbing influence of the mountains would be demonstrated in the most conclusive manner, and thus justify...the propriety of terminating the arc at Kaliana, which is 69 miles south of Banog. ...

How Colonel Everest, who in the year 1837 took azimuth observations for the express purpose of ascertaining the effect produced by a known...cause, ... should be...misrepresented as ignorant of the cause, ... is so unreasonable...that further disproof seems unnecessary. Long prior to Captain Shortrede's arrival at headquarters...orders had been issued to Captain Renny and myself to record...local appearances at every station at which we observed azimuths.

Captain Shortrede's recollection of his conversations with Colonel Everest are strangely at variance with the latter officer's known opinions.

[1] Everest disliked discussing subjects on which he had made up his mind [IV, t-page, 259]. [2] DDn. 451 (387-408), Shortrede to Mil. Dept., 31-5-45. [3] TS. 7.

Waugh went on to analyse the several sections of the Great Arc, comparing them with meridional arcs measured in other parts of the world, and showed in the most incontrovertible manner that the sections of the Indian Arc, the two northern of which were entirely measured by Colonel Everest, do not shrink from the application of a test under which every other measured arc, that I am aware of, fails. ... Government...may ... rely with implicit confidence on the superior merits of the Trigonometrical Survey of India[1]. The Directors accepted Waugh's verdict and passed the correspondence to Everest, pressing for completion of his final report, the Great Arc book of 1847 [IV, 113].

Shortrede was persistent, and repeated his views in a paper read before the Royal Astronomical Society on 18th June 1848. This attracted the attention of Airy, the Astronomer Royal, who suggested a few slight amendments. Shortrede then forwarded a printed copy of his paper, with a copy of Airy's appreciation, to the Government of India, still claiming that the deflection at Kaliāna "has been glossed over in Col. Everest's lately printed book, and kept out of view by altering all the calculated latitudes in the northern section of the Arc"[2].

Waugh passed the papers to Radhanath Sickdhar at Calcutta ;

As you were present at headquarters at the time the computations were made you are better acquainted with the subject...than any other person. ... I should wish steps to be taken to verify...the data taken by Captain Shortrede from the Trigonometrical Survey. The accuracy of his observations can only be tested by repeating them with better instruments, ... which I propose to undertake on the first favourable opportunity. ...

Captain Shortrede...is very ingenious. ... He does assume that there is no great variation of aspect in the situations of Dehra and Kaliana. ... Herein consists his mistake, for in reality the change is enormous. ... Dehra is at the foot of the range from which Kaliana is distant 60 miles, and no less than about 140 miles...from the centre of attraction. ...

Dehra is one of the most unsuitable localities that could have been chosen for investigating the quantity of attraction at Kaliana with any approach to accuracy. It is not a principal station of the Arc, but an intersected point, ... the chimney of a house.

Its position at the very foot of a mountain range upwards of a mile in height, and only 7 miles distant, must greatly enhance the attraction in a meridional direction, which cannot fairly be compared with the azimuthal disturbance observed at...Banog on the top of the mountain. ... It is my intention to observe for latitude at Banog in order that all doubt may be set at rest, but in the meantime it will be clear...that—the azimuth having been observed at the mountain top and the latitude...at its base—no fair comparison can be instituted. ...

Respecting Col. Everest's having glossed over the effects of attraction, it appears to me not warranted by the facts which are all fully stated, and the mode of dispersion explained, in... his printed work. ... The results only are printed, ... but every detail is explained. The computations are, however, recorded in complete detail in the manuscript copy of the General Report which was placed at the disposal of the Astronomer Royal[3].

Radhanath sent the information required, and welcomed the proposal to test Shortrede's conclusions by observations at Banog, commenting shrewdly that the latitude and azimuth observations at Banog will furnish the measure and direction of the deflection...at that station only...[and] furnish no idea as to the average amount, and general direction, of the Himalayan attraction in the plains. To obtain this result, latitude and azimuth observations will...require to be made at stations from twenty to thirty miles apart along the whole line of the North Longitudinal or Connecting series [IV, 71 ; V, 132 n.7][4].

Waugh then replied to Government that

Captain Shortrede's paper appears to be entirely of a conjectural character, and no reliance can be placed on the results. ... The supposition of a constant centre of attraction on which his hypothesis rests is totally inconsistent with the conditions actually existing. ...

The Himalaya mountains form an immense chain of indefinite length and breadth, composed of enormous irregular masses of various height, with deep intervening valleys. ... The change of aspect produced by an approach from Kaliana to Dehra and Banog must be enormous. ...

Dehra is at the foot of the mountain range, and Banog on the summit, and they are treated as identically similar. Captain Shortrede resided nearly 6 months as Colonel Everest's guest within five miles of Banog mountain. I cannot therefore understand why he preferred taking his observations at the foot of the mountain instead of on the same spot at which the error in azimuth had been previously ascertained by Colonel Everest[5] [IV, 95, 104].

[1] DDn. 452 (277-97, paras 12, 38), 28-7-45. [2] DDn. 541 (109), to Mil. Dept., 8-1-50. [3] DDn. 566 (59), 14-3-50. [4] DDn. 567 (6), Ch. Compr. to SG., 24-5-50. [5] DDn. 542 (92), 12-10-50.

The observations for latitude on Banog taken by Renny-Tailyour in 1851–2 [137–8] confirmed Waugh's suggestion that the effect of Himālayan attraction might be less at Banog than at Dehra Dūn where Shortrede had observed[1].

During the summer of 1853 Archdeacon Pratt of Calcutta, an able mathematician, visited Mussoorie and, becoming greatly interested in the Surveyor General's problem, enjoyed a visit to the summit of Banog. Renny-Tailyour sent him a copy of Shortrede's paper, "chiefly because he has been at the trouble of extracting all that bears on the subject...from Col. Everest's Arc Book"[2].

Pratt pointed out that the problem involved the effect of an unknown attraction on the computed values of latitude and azimuth brought up by precise triangulation from a distant origin, that might itself be slightly affected by some local attraction. The only measure of the amount of this "deflection" so far applied had been that of astronomical observations. These, wrote Pratt, cannot "eliminate or determine this troublesome intruder. Recourse must be had to new and entirely independent calculation and measurements".

I feel convinced that the only way to supply the desideratum is to dissect the Himalayas and actually calculate the attraction. This may appear at first to be a most gigantic undertaking, but...it is feasible after you have completed your general survey of the mountains, and laid down the heights and depths. ... The Great Trigonometrical Survey of India, owing to the great extent of its area, is so important a work in its bearings on physical astronomy that no reasonable amount of labour should be spared to make its results available[3].

Waugh accepted this suggestion as eminently sound ;

I was sensible that the best mode of effecting this object would be to calculate the sum of the attractions of the mountain masses taken in parts, or piecemeal, and...gave this as my opinion to Government in a report dated 28th July '45 [135 n.1][4], but I represented it as an herculean undertaking, not being aware that the process might be simplified as shown in your letter, from which I derive great encouragement.

He thought that the topographical survey by the North-West Himālaya series would provide sufficient information to the west, but doubted whether the old surveys of Hodgson, Herbert, and Webb would give sufficient detail to the east. He further pointed out that Everest himself had wondered whether Kaliāna was sufficiently distant from the mountain mass ;

When the calculations were brought up in 1841, the effect of Himalayan attraction became known, and the question was whether another northern station should be selected further from the attracting mass.. But, as Government was urgent to close the scientific part of the survey, Colonel Everest had no alternative but to leave this duty to his successor[5] [IV, 101–2].

Pratt followed up by reading a paper before the Royal Society on 7th December 1854, entitled *Attraction of the Himalaya Mountains on the Plumb-line in India*, and he continued to work at the subject till his publication in 1865 of *A Treatise on Attraction, La Place's Functions, and the Figure of the Earth*. He sent Waugh a diagram shewing the general height of the mountains—sector by sector—to the north of Kaliāna, and asking for information about conformation and height in the neighbourhood of the terminals of the several sections of the Great Arc ;

A few months ago I forwarded to you...a copy of a paper lately printed in the Philosophical Transactions *On Himalayan Attraction*, about which I wrote to you...in September 1853 from the Cape. ...By the help of your maps you will be able in a moment to see whereabouts in the mountain mass the compartments of my diagram lie.

Hennessey was too busy on other work to take up the task suggested[6], but Tennant suggested that the results of the longitudinal arc Kaliānpur to Karāchi might help. In a paper read at Calcutta, 21st July 1859, Pratt discusses "the influence of Mountain Attraction on determination of the relative heights of Mount Everest... and the lofty peak discovered near Kashmir"[7] [87–9] suggesting that

mountain attraction [may] cause the survey to make the height of the newly discovered mountain [K 2] too low by 150 to 200 feet relative to Mount Everest. The plains at the foot

[1] DDn. 569 (161–2) Renny-Tailyour to Pratt, 23–6–53 ; *GTS.*, XI (10). [2] DDn. 569 (161–2), 23–6–53. [3] DDn. 545 (393), Pratt to SG. 11–7–53. [4] DDn. 452 (277–97), paras. 17, 29. [5] DDn. 543 (77), SG. to Pratt, 9–8–53. [6] DDn. 32 (30–3), Pratt to SG., 4–2–56 ; note by Hennessey, 3–4–56. [7] *RAS.* (*mn*), XVI, 1855–6 (36–41) ; DDn. 32 (102–6 ; 111–6), 24–9–56, *et seq.*

of the Darjeeling Hills are higher above the sea level than the survey makes them by 189 feet and the plains at the foot of Kashmir are higher than the survey make them by 291 feet [66][1].

The whole subject now attracted wide attention, suggesting the value of pendulum observations for the determination of variations of gravity, and introducing the theory of compensation or isostasy. Amongst the many scientists who have contributed to the development of modern ideas on the subject are Stokes—Airy[2]—Helmert—Hayford—Burrard—De Graaff Hunter. Departmental publications on the subject include ;

Accounts of the Operations of the G.T.S. XVIII (521) ; Alphabetical List of deflections deduced.

Special Report	No. 5.	*Report on Local Attraction in India, 1893-94,* Burrard Dehra Dun, 1895.
Professional Paper	No. 5.	*The Attraction of the Hima'aya Mountains upon the Plumb-line in India.* Burrard, Dehra Dun, 2nd edn. 1901.
	No. 13.	*Investigation of the Theory of Isostasy in India.* Crosthwait Dehra Dun, 1912.
	No. 17.	*Investigations of Isostasy in Himalayan & Neighbouring Regions.* Burrard, Dehra Dun, 1918.
	No. 18.	A Criticism of Mr. R. D. Oldham's memoir "*The Structure of the Himalayas*". Cowie, Dehra Dun, 1921.
Departmental Paper	No. 12.	*Geodesy.* De Graaff Hunter, Dehra Dun, 1929.

A paper by Pratt dated December 1869, was printed at Dehra Dūn by the Trigonometrical Survey under the title "On the effect of gravity at Kaliana, Kalianpur, & Damargida produced by the irregularities of the...Earth's crust"[3].

Waugh's Manuscripts include a note on "A method of calculating the Horizontal Attraction...arising from the combined effect of the excess and defect of matter"[4].

DEPARTMENTAL OBSERVATORIES

Banog hill station was fixed by Everest in 1835 as the Himālayan terminus of the Great Arc. In 1837 he and Waugh found here a deflection of 22″ in azimuth. Standing 7,429 ft., above the sea[5], it is about a mile north-west of Everest's house, The Park, and connected by a bridle-path constructed in 1835 [IV, 163]. It lies about 3 miles west of Mussoorie, and is easily accessible. It commands a grand view in all directions, with the Chaur peak to the west, Bandarpūnch and the snow range to the north, Sahāranpur, the Ganges and Jumna rivers to the south. It was later made the terminal to the line of spirit levels brought up from Karāchi[6].

Though the station was not so accessible in Waugh's time as when Everest had his summer headquarters at the Park, it was still frequently visited, and in 1851 a temporary observatory was constructed and steps taken to secure the summit as the permanent property of the Department, Renny writing to the Government of the North-Western Provinces ;

> The observatory is required for determining the latitude and Himalayan attraction [135–6]—for barometrical experiments in connection with the geodetical heights brought up from the sea [66, 69]—and the examination of instruments, especially theodolites—for which the isolated position of the station, and the number of known angles given by surrounding stations afford peculiar facilities. The preservation of the station is, moreover, of great importance as being the transfer point of the Dehra Doon base, and the point of union of three principal series, viz., the Great Arc, and the North-West and North-East longitudinal series. ...
>
> The ground at present occupied by the observatory buildings, and required for the encampment of the observer party, may be defined, ... reckoned from the station mark, viz.—on the north, up to the precipice, or about 50 yards—on the east 300 yards—to the south 100 yards—and to the west 150 yards[7].

The local Commissioners of Mussoorie were ready to allot this plot to the Survēy as public land under their control. They pointed out that within the past

[1] *JASB.* XXVIII, 1859 (314) ; Montgomerie found deflections up to 22″ in Kashmir [234]. [2] v. Airy's paper read 15-2-58 ; *Phil Trans.* 1858 (101–4). [3] GBO. Lib., H-p-4. [4] Waugh MSS., II. [5] upper markstone, 7,433 ft.; *GTS. Trig. 63 J.* [6] view from north., frpce. *GTS.* XIX. [7] DDn. 569 (1), 7-2-52.

year the Survey had not only erected "an observatory on the Peak", but had also built "a private dwelling house...below it". Renny explained that

on Banog, ... an isolated peak that has frequently been struck by lightning, it was both a matter of convenience and economy to place the necessary accommodation [for observers and establishment] on a lower level, but the small bungalow, ... which...does not exceed an ordinary office tent, is certainly within 60 yards of the observatory[1].

In the course of a somewhat bitter correspondence on the fairness of charging rent for this plot of public land, Waugh pointed out that

Colonel Everest...did not contemplate astronomical observation at Banog because the question... of Himalayan attraction had not been raised. Hence he did not build an observatory there but he occupied the land without question or dispute as often as he required it. ... Every public observatory all over the world stands on public or municipal ground[2].

The N.W.P. Government thereupon declared this plot of just under 7 acres, "marked out by 13 pillars of masonry", including "a pucka observatory and a chuppered bungalow" built in 1851, to be granted to the Surveyor General. Rent at Rs. 4-3-0 per annum, 2 annas a *bigha* for 33½ *bighas*, was paid to the Commissioners of Mussoorie, and charged to Government by contingent bill[3].

Beyond this correspondence no record nor tradition has been found of the construction or demolition of a *pucka* observatory on the peak, and the records describe the hill station as marked by a solid pillar 2 ft. high, with upper and lower markstones. It is now protected by a rough stone cairn several feet high. There is no trace of any masonry observatory, but the ruins of the small four-roomed dwelling for the observer still stands [1951] in a cluster of trees about 150 yards to the south-east of the station cairn.

Banog observatory was soon abandoned; Waugh noting that

up to 1852 Banog was made the observatory of instruction. This entailed much expense and inconvenience, and the entire day was lost for office. When Major Renny-Tailyour instructed Lieut. Walker, the interruption to other business was felt to be so great that the Surveyor General built an observatory at his private expense at Lauriston[4].

Col. Waugh's private observatory is too confined for teaching many together. ... When Simm's 24-inch theodolite was altered by Mr. Cribble and Major Strange [154], they complained for want of room, and the distance from office and the workshop was peculiarly inconvenient. Last season Lieut. Tennant had to clean and adjust the Great Theodolite in the verandah at great risk, and the lathe and workpeople had to be put into Col. Waugh's office room to the interruption of his business[5].

Waugh then recommended the construction of a new building close to his office which was constructed at a cost of about Rs. 900 and it was ordered that

the new observatory room being ready for reception of instruments, Lieut. Tennant and H. Keelan, Esq., will...take a favourable opportunity of examining all the large theodolites in the headquarters depot with the view of selecting one for the Great Indus series, ... and another for the Rahoon meridional series, and putting them in order[6].

It is not clear whether this last observatory was identical with the Mussoorie Dome Observatory H.S., established and destroyed before 1868. This was "situated on...the Camel's Back, to the west of, and considerably below, the highest part of the hill. A few yards to the E.S.E. is the transit room, and a little below on the northern face of the hill, is the house formerly occupied by the Great Trigonometrical Survey office"[7].

There was also an observatory at Dehra Dūn situated on the right bank of the Rispana *nadi*, in the compound of the headquarters office of the Great Trigonometrical Survey, "Zephyr Hall", No. 12 [or 14?] Old Survey Road[8] [133].

The observatory at the Surveyor General's office at Calcutta was maintained by the Computing Office which made regular meteorological observations [139-40], and took daily observations for time for the control of the time-ball at Fort William [IV, 113-5; V, 356-7]. The primary purpose of this observatory, had, however,

[1] DDn. 569 (2), Renny to NWP., Govt., 10-4-52. [2] DDn. 542 (300), SG. to NWP. Govt., 30-4-52. [3] Grant 239 of 1-5-52; DDn. 545 (153-5), Commr. Meerut, 19-8-52. [4] Lauriston Obsy., Camel's Back, 6,654 ft.; Zephyr Hall, old obsy., 6,726 ft.; v. OBO Lib. maps A (2), E (5). [5] DDn. 14 (17-8), 31-3-57. [6] ib. (37), 27-5-58. [7] *GTS. Trig. 53 J*; Dehra (2-3). [8] about 3 fur. E. of St. Thomas' Ch. and 6 fur. E. of Walker Obsy. in present Svy. compound; v. OBO Lib. maps A, 3, 4, 7, 9; DDn. Svys., 1865, 1875.

been the maintenance of regular observations for time, barometer, and thermometer, to meet the needs of mariners and field surveyors [III, 186–9 ; V, *inf.*, 356–7].

METEOROLOGY

The taking of regular meteorological observations had long been of interest to surveyors in India, and had been included amongst the functions of the observatory which Blacker established in Calcutta in 1825 [III, 273]. Copies of the meteorological registers were much in demand [IV, 119–20], and in 1844 formal sanction was given by the Governor General in Council for extracts to be published daily in the Calcutta newspaper, *The Englishman*[1]. In 1848 no fewer than 21 copies were being sent out every month. In 1849 copies of the full registers from 1833 to 1849 were sent to the Bombay Geographical Society, on whose behalf Dr. Buist was collecting date from all directions [69 n.5] ;

Anxious to investigate the phenomena and laws of atmospheric pressure from the Line [Equator] northwards, they [the Society] have endeavoured to place themselves in communication with every observer and observatory in the East. ...

They have already been able to trace out a regular law by which the daily tides of the barometer decrease, while the yearly range and casual irregularities increase as the equator is receded from. ... At Calcutta the extreme yearly range exceeds an inch. ... From Lucknow, the northernmost station in India from which regular barometric returns...have been received, to Madras and Trivandrum, the minimum pressure for the year occurs with very few exceptions in June, the maximum in December and January. ...

It will be seen how valuable...are observations such as those you have sent, ... and how eminently serviceable it will be...to have them continued[2].

Up to 1852 the meteorological records as well as time observations and daily signals to Fort William were conducted by Vincent Rees [IV, 462 ; V, 356] who paid his single assistant from his own salary of Rs. 300. The Surveyor General agreed with Thuillier that the registers maintained were inadequate ;

I see with much concern that the register exhibits nearly a complete blank. ... Without the night curves and hourly observations the register cannot be considered in keeping with the present state of meteorological science. It is...unworthy of the metropolis of India, as well as a source of anxiety to all concerned. ... The addition of two qualified assistants...of good education...would secure all that is necessary[3].

Before anything came of this suggestion a call came from the Directors for the establishment of regular meteorological observations from one end of India to another[4]. After consulting the Surveyor General and others, the Government of India recommended the establishment of observatories, under medical officers rather than engineers, at 15 stations, of which six fell in north India—Calcutta—Lucknow—Murree—Landour—Lahore—Ambāla.

Observations will be as usual recorded at the observatory in Calcutta under...the Deputy Surveyor General. ... The results of the Bengal observations will be forwarded...to the Surveyor General's office in Calcutta for reduction and arrangement previously to being transmitted to England. Some small addition to his establishment may be necessary for this purpose.

The observations taken in the other presidencies may be...arranged under the supervision of the Astronomers at Madras and Colaba[5].

The Surveyor General asked for an increase of establishment. The observatory at Calcutta had not been "intended for the furtherance of general science like the Madras Observatory, but solely for comparative observations connected with the Survey Department, ... a zero point in altitude and departure for the various surveys" [*sup*].

One head and 3 assistant observers and recorders were duly sanctioned, as well as two assistants for reducing the observations received from up-country stations[6]. Later in the year the Directors ordered that this work should be carried out "by

[1] *JASB.* XXII 1853 (508, 610) ; DDn. 453 (156), SG. to *Englishman*, 11–7–54. [2] DDn. 467 (141–3), Buist to DSG., 25–7–49 ; *IO Cat.* (626), obsns. by Buist. 1842–3, Fergusson 1852–63. [3] DDn. 561 (150), 12–12–50 ; (388), Rees to DSG., 3–1–51. [4] proposed by Sir John Fox Burgoyne (1782–1871), *DNB.*, RE. ; of HM. Bd. of Ordn. ; Markham (289). [5] DDn. 546 (3), B to CD. (mil.), 9–4–52. [6] DDn. 546 (23), 5–3–52.

the Surgeon in charge of the Medical College Hospital" at Calcutta, which they reversed after strong protest by the Surveyor General[1].

Rees had now retired, and the observatory was placed under the Chief Computer, who reported in June 1853 that he had three observers taking hourly observations, and two computers reducing these to proper form. The records covered

reduction of observed height of barometer—depression of wet below dry bulb of thermometer—dew point—elastic force of vapour—weight of vapour—additional weight of vapour for complete saturation—humidity—weight of a cubic foot of air.

All to be computed for every one of the 24 observations made during the day[2].

These observations continued till the retirement of Radhanath Sickdhar in 1862. The Meteorological Department of the Government of India was established from 1874[3], and under its direction the Survey has maintained continuous meteorological observations at Dehra Dūn up to the present day.

ELECTRIC TELEGRAPH

The line of visual telegraph towers between Calcutta and Chunār had been laid out by George Everest in 1818 before joining the Great Trigonometrical Survey [III, 269-72][4] but the Surveyor General's Department had little to do with the start of Electric Telegraphs in India beyond supplying maps.

In September 1839 Dr. William O'Shaughnessy, Professor of Chemistry at the Medical College, Calcutta, read a paper before the Asiatic Society on his "Experiments on the Communication of Telegraph Signals by induced Electricity." He continued his researches and in 1851 was appointed Superintendent of Telegraphs, becoming the first Director General of the Telegraph Department in 1853[5].

In January 1847 the Deputy Surveyor General was called on to provide a map shewing "the line of country from Fort William to Diamond Harbour, it being in contemplation by Government to establish a line of Electric Telegraphs to the sea" [15]. This line was actually laid in 1851, and extended to Kedgree the following year, O'Shaughnessy reporting on 31st March 1852 that

the conductor has been laid across the Hooghly River, defended by a massive chain cable. The operations were completed on the 29th inst., when a message to Kedgree regarding a steamer was despatched from Calcutta, and the answer received in seven minutes[6].

In 1854, at the suggestion of Edward Williams, of Engineers [195], Thuillier proposed to work the Fort William time-ball by means of electric connection from the Surveyor General's office in place of the simple visual signal ;

Immediately on the arrival of Dr. O'Shaughnessy...in Calcutta in October or November last, I took occasion to consult him, ... knowing that the inventor of the mechanical contrivance by which the ball is dropped in the Strand, London, from a signal at the Greenwich Observatory, ... was then in Calcutta [Mr. Shepherd], but the Superintendent informed me his hands were then so full, and the materials for the long lines so urgently required, that he could not at that moment hold out any hopes of being able to attend to such a requisition[7].

The connection was eventually installed in June 1858 but was not an immediate success [357], and Thuillier reports a year later that the apparatus

at the Semaphore Tower was originally put up in a very inefficient manner and, until the whole was taken down and renewed by...the Superintendent of the Electric Telegraph Workshops, no good results could be obtained. ... I...hope...that with the present arrangement the shewing of Mean Time will be satisfactorily performed and that we shall be spared the serious disappointments and vexations which the business has entailed on us for some time past[8].

Responsibility for the signals rested with the Chief Computer, and in 1860 he was still reporting repeated failures ; "Two artificers daily attend the semaphore tower ; ...one is supplied by the Electric Telegraph, and the other by the Mathematical Instrument Maker's Department. ... These two persons do not agree".

[1] DDn. 555 (15), DSG. to SG., 25-11-52 ; DDn. 551 (89), Mil. Dept. to SG., 31-3 53. CD. to B. ; 28-6-54 (14). [2] DDn. 563 (77-81), Ch. Compr. to DSG., 17-6-53. [3] under Henry Francis Blanford (1834-93), *DNB*. [4] *IHRC*., XXVII/3 (78). [5] *JASB*., VIII, 1839 (714-31). [6] *Ben Sel*., 190S. [7] DDn. 556 (43-4), DSG. to SG., July 1854 ; Chas Shepherd, London clockmaker, granted patent for electric clock, 1849 ; worked for Greenwich Obsy. & RN. [8] DDn. 668 (133), to Home Dept., 31-5-59.

There had been 14 failures, probably due to breaks on the main connecting line, between September 1859 and May 1860 "whilst on 18th and 19th May the ball was not hoisted". The telegraph *mistri* drew Rs. 12 a month, and his assistant Rs. 8[1]. The new technique was eventually mastered, and signals were carried on by the Survey office till handed over to the Telegraph Department in 1905 [IV, 115].

The Survey was likewise associated with the first trials of the telephone in India, which were made in 1877 by an officer of the Telegraph Department. The existing wire from the Surveyor General's Office to the Fort was the medium of communication, and the human voice was distinctly heard at both ends[2].

From 1855 there are constant references to orders passing by telegraph to Surveyors in the field, and several instances of surveyors working with the new department. In 1854 Du Vernet was transferred to be Superintendent of the Telegraph Department in Burma, and in 1855, after the war, he saw the line carried over 200 miles from Rangoon to Meady above Prome [196, 375, 395]. During 1857 Nasmyth was authorised to help in the lay-out of the line through Cutch, his assistant Sanger being deputed on this work for some months. The Surveyor General was, however, cautious in giving his approval ;

I am anxious that our Department should...make itself useful in all practical ways; at the same time, it would not be politic to sacrifice the progress of the survey. If there be any objects more than others worthy of a sacrifice, it is military service and the telegraph, and I should be very glad to show our readiness to comply with His Lordship's wishes. ... If it is in your power to render the assistance asked for, ... I authorise your doing so at once[3].

In 1865 Robinson was transferred to officiate as Director General of the Telegraph Department, and his appointment was confirmed the following year [388].

PHOTOGRAPHY

Photography for map-making purposes was started in a small way at Calcutta in 1862 [331]. In 1866, Hennessey brought out from the Ordnance Survey in England a complete apparatus for photo-lithography, which was set up under his direction in the office of the Trigonometrical Survey at Dehra Dūn. Here he instructed several survey officers in the new process, one of whom, Arthur Melville, already a skilled amateur photographer, took charge in April 1867 of the cameras which had now been established at Calcutta [331].

Melville had taken a series of interesting photographs whilst on the Kashmir survey, Government having at Montgomerie's request authorised the purchase of apparatus to the value of Rs. 1,200 and the cost of its maintenance [235].

Views of Kashmir and Ladak and of their various architectural structures, Buddhist and others, added to accurate delineations of all such objects as bear upon ethnological inquiries, natural history, etc., would, with the maps and reports, supply all that is wanting to make our information about these interesting countries complete[4]. ...

In addition, I am very sanguine that a skilful photographer may be able to do something in the way of copying our maps, and thus put the published maps more nearly on a level with the original than they have hitherto been [331][5].

It had been proposed to post to the Kashmir survey a young Engineer officer known to be a skilled photographer, but this was prevented by the outbreak of the mutiny, and the work was entrusted to Melville. In 1863 twelve copies each of his best photographs were distributed to the Governments of India and the Punjab, and to the India Office in London.

His Highness the Maharaja [Ranbir Singh]	Boatman pounding Rice	Dogra Sepoys
Kashmir Dancing Girls	Kashmiri Boats	Court Chuprasis
Shawl-makers	Weighing Rice	Boat Girls
		Irreguar Troops.

[1] DDn. 34 (6-25); from Ch. Compr. to SG., 5-5-to 13-7-60. [2] *Statesman*, 27-11-77. [3] DDn. 718 (463) to Nasmyth, 18-1-58. [4] *JASB.* XXXIV, 1865 (7-9); 10 silver prints of Ladākh "mystic play" by Melville. [5] DDn. 51 (27), Montgomerie to SG., 19-5-57.

James Mulheran was another keen photographer, and whilst in charge of the Hyderābād survey took a number of interesting photographs of the people and country, and sent copies officially to the Surveyor General.

In 1861 Walker suggested that Branfill's knowledge of photography "may prove of great utility in enabling us to copy and reduce our maps" [331][1].

GEOLOGY

Dr. Voysey was appointed to the Great Trigonometrical Survey in 1818 as medical officer and geologist in response to Lambton's request for a scientific adviser for the siting of survey stations, but no successor was ever appointed [III, 264–6] though both Everest and Waugh were interested in geology, a subject of particular appeal to all surveyors [III, 266–9].

Walter Sherwill, of the revenue survey, spent much of his spare time in the study of geology during his survey of Bihār, or Gaya, District, and early in 1845 sent the Asiatic Society at Calcutta "a beautiful geological map and collection of specimens of zillah Behar", with a "general geological memorandum of the district", which the Society brought to the notice of the Governor-General,

that gentleman having, in the intervals snatched from the very laborious duties of a Survey officer, constructed a beautiful geological map of the province of Behar, and made a valuable collection of 375 large specimens to illustrate it, together with a memoir, all of which he has placed at the disposal of the Asiatic Society[2].

In 1848 his geological map of Monghyr and Bhāgalpur was lithographed, and had a wide sale[3]. His later maps include a

Geological Map of the northern front of the Vindhya Hills, ... Allahabad to Rajmahal, showing the position of all the known coal-beds of that tract, also of the silver, copper, lead, and antimony localities, as well as the principal iron measures. ... By Captain Walter Sherwill, Revenue Surveyor, between the years 1842 and 1851. 1 inch to 8 miles, with large-scale cross sections[4].

There is also a geological map of the Palāmau coal-fields by William Sage, of the Public Works Department[5] [IV, 464].

In 1837, before Sherwill joined the survey, Dr. John McClelland [IV, 204] had been appointed Secretary to a newly formed "Committee for the Investigation of the Coal and Mineral Resources of India". On his recommendation a professional geologist, David Williams[6], came out in 1845 from the Geological Survey in England to survey the coalfields of Bengal. Williams died at Hazāribāgh three years later, and McClelland was appointed to act as "officiating Geological Surveyor" until the post was abolished from 1st April 1850, "as the Hon'ble the Court of Directors have resolved to secure the services in England of a successor to the late Mr. Williams, and no work is now in hand except...the printing of your report". Two assistants, Theobald and Gomez, were kept on under the Deputy Surveyor General till 30th April, and a third,

Mr. Haddon, being at present engaged on the survey and drainage of the swamps at Purneah [245], is to be considered on detached duty...under the orders of the civil authority at that station. ... As soon as he has completed the work...he will, in the event of your successor not arriving from England, be under the orders of the Deputy Surveyor General[7].

In March 1851 Thomas Oldham arrived from England and assumed charge as Superintendent of the Geological Survey of India.

In August 1851 Saxton, in charge of the topographical survey of Ganjam and Orissa, asked that a special allowance should be granted to the assistant surgeon in medical charge of his party, for reporting on geology and natural history. The Surveyor General would not support him, being of opinion that

[1] DDn. 25 (8), STS. to SG., 25–4–61. [2] *JASB.*, XIV (lxii–v); *Progs.*, 17–6 & 12–8–45; DLR., 37/57 (182). [3] *JASB.* XV, 1846 (55–9); XVI (279–84) (384), XVII (702); *Progs.*, 6–12–48. [4] DLR. 37/57 (204), 3–8–51; 37/59, 3–10–53; 37/70 (78), 24–4–57, MRIO. 17 (42–A), 59 (25–6, 35); *IO Cat.* (167). MRIO., 59 (30–1). [5] arrd. Calcutta, 4–2–45; d., Hazāribāgh, 25–11–48; MRIO. 60 (27), Geol. Map NE. from Hazāribāgh, Williams & McClelland, 1847–8. [6] DDn. 469 (25–8), to McClelland, 13 & 26–3–50; R. G. Haddon, Raniganj coalfield 1846–7; d. 1857.

no advantage can be expected to science from desultory researches in Botany and Geology such as medical officers attached temporarily to a survey could institute. These undertakings should be organised systematically on a great scale, and follow the labours of the surveyor[1] [171–2].

Oldham was most anxious for good maps and wrote three years later that,

for the intended examination of the Nerbudda valley during the coming cold season, ... there exist no maps. There are maps of the Gwalior territory...on the west, and also of the Sohagpoor and Ramgarh districts of the Saugor and Narbudda territories, but of the district between no maps exist. ... It is most probable that within this unmapped country the most promising mineral localities will be found.

I would...suggest...directing the early attention...of the Revenue Survey...to this district, as it is quite impossible to render the geological examination...fully useful...without good maps on which to record the observations[2].

It was also in 1854 that the Directors sent out several copies of a geological map by George Greenhaugh, and asked that these should be distributed to officers who might be in a position to add to or correct them[3]. Government thereupon directed that Saxton should "combine an investigation of the mineral resources of the country with the topographical survey he is now conducting". Saxton had told the local civil Superintendent that he had

made collections of minerals from the beds of rivers and nullahs, and last year sent specimens to Dr. Hunter, a great geologist in Madras, who returned my samples named, and their values given. ... Mineral research is worthy of notice. My collections last season were much more extensive ; I have a large quantity of cornelians[4].

He asked the Surveyor General for official directions and pointed to his report for season 1853–4 in which he had noted on

the iron, coal, and lime in the Talcher and Denkanal estates, and to my narrative report of last season...with reference to the coal in Gangpur estate, to show that...I have not neglected...opportunities of...collecting information on important geological features. ...

It has been published in the first Journal of the Presidency to which I belong [Madras]... that I have been appointed as head of a Geological Survey of Orissa. ... I could now furnish a cart-load of mineral specimens of my own collecting, including water from hot springs. But they are wanting in scientific arrangement which a professional geologist would give them[5].

Waugh asked the advice of Henry Medlicott, Professor of Geology at Roorkee as to how Saxton or any other surveyor untrained in geological science could best contribute to local knowledge. Medlicott gave advice—as to books to be read, objects to be searched for, the collection and labelling of specimens—which was passed to the Deputy Surveyor General for communication to Saxton, now placed under his direct orders [348] ;

I would...caution him for the present...to avoid theorising, and devote himself to localising facts. ... As a Surveyor, to mark down the positions and limits of geological and mineral formations, and collect specimens, which should be sent to Mr. Piddington [of ASB], or to the Geological Department, for examination, nomenclature, and report. ...

Until accurate and complete maps on a sufficient scale are prepared and published, the geological survey must languish, or lose a great deal of its value. ... Hence the work of major importance is to push on the topographical survey as fast as it can be made to progress without sacrifice of accuracy [171–2].

Thuillier was authorized to provide text-books and specimen cabinets, and Saxton was directed to submit geological reports through his office.

All expense incurred on account of mineralogical investigation is to be kept by Captain Saxton separate and distinct from topographical operations, and he will assign...a fair proportion of the general expenses of establishment to the head of mineralogical investigation. ...

I do not expect that Captain Saxton and his assistants will by their...researches supersede the necessity for a regular Geological Survey hereafter, when maps are ready for geologists to base their researches on, but...it may...be possible...to produce information sufficient in quantity and accuracy to serve as a first pioneering exploration. ... Surveying is a profession which requires exclusive devotion to achieve much above mediocrity [t-page][6].

[1] DDn. 577 (7), SG. to Saxton, 10–9–51. [2] DDn. 552 (4), 16–8–54. [3] *JASB.*, IX (942), 3–1–41, Geol. Map, England & Wales, by Greenhaugh; 1st edn., 1819, 2nd. 1840; DDn. 662 (51), CD. to B., 27–9–54; Geol. map of India, 9 sheets, *IO Cat.* (90). [4] DDn. 548 (56), Saxton to Supt. Trib. Mahāls. [5] DDn. 429 (2), Mad. Govt. to Saxton, 22–6–55; Saxton to SG., 4–7–55. [6] DDn. 665 (101), SG. to DSG., 26–9–55.

Oldham warmly endorsed these arrangements and offered cordial assistance;

A portion of my staff [Blanford & Theobald][1] proceed tomorrow into the district of Cuttack to carry out the geological examination of that country, and if Captain Saxton could join them...he would probably learn more in a few days than by months of mere book study[2].

Saxton spent several profitable days with Blanford in the Angul State and Piddington gave useful hints about collecting specimens, noting that it was

an utter waste of time for the Surveyor to attempt naming his specimens. The locality and ...description...of the rock, vein, or outcrop of the specimen is all that is required. ... Where mines, whether worked or abandoned, are found, where mineral substances...evidently exist, not only should specimens be sent in good quantities, ... a seer or two at least, but particular care should be taken to send a lot of the rubbish, and of the vein, stones, or walls. These may contain more valuable products than the showy lead or copper ore. ...

But...consider what a fascinating pursuit Geology is, and how easily a young and zealous and valuable officer may be led to overwork himself[3].

In 1861 Oldham pressed for the early printing of Robinson's survey of Rāwalpindi and Jhelum on scale one-inch to the mile [214];

The great importance of a sound knowledge of the geological structure of the Salt Range... has more than once been insisted on. ... Up to the present time, however, this has been impracticable, inasmuch as no maps...existed of sufficient accuracy. ... This difficulty has now been removed by the preparation of the very beautiful and accurate maps...under Captain Robinson. ... The maps, however, exist as yet only in manuscript. ...

I would...press very strongly the urgent want of good maps of that part of the country, the very high importance of the district, both geologically and commercially, and the great desirability of these maps, on the larger scale of one inch to the mile, being brought forward as quickly as convenient. ... The entire cost of putting these on stone so that...many hundred copies...could be procured, would not exceed the cost of making two MS. copies.

If there were a fair prospect of these maps being available to the Geological Survey in 1862. arrangements could be made so as to enable us to take up the examination of this district in the following season[4].

During 1851–2 a geological survey, "a rough military sketch", had been made of the Salt Range by William Purdon and William Theobald, working under the direction of Dr. Andrew Fleming[5].

It has since been the general rule to adjust the programme of topographical surveys to meet the needs of the Geological survey so far as possible.

THE SCHLAGINTWEIT BROTHERS

In 1839, at the instance of the Royal Society, the Court of Directors had instituted a magnetic survey of their eastern territories by the establishment of observatories at Singapore, Madras, and Simla [IV, 117–9]. The observatory at Simla conducted by John Boileau had been closed down in 1845 after producing a mass of valuable information. Singapore had been under charge of Charles Elliot[6].

In April 1853 the Royal Society was approached by the German Embassy in London with a proposition from Baron Humboldt [III, 525] for support for a scientific mission to the Himālayan mountains by two German scientists, Hermann and Adolf Schlagintweit, who had already done useful work in the European Alps.

They confidently hope that...a considerable chasm in the chain of our magnetic observations would be filled, and that a stay of about three years in those regions would enable them to accomplish many more objects in the interest of science. ... His Majesty [King of Germany] would be most happy to place, for the term of three years, the yearly sum of 5,200 sterling at the disposal of the Royal Society if an expedition of that sort could be assisted[7].

This was passed to the Court of Directors who welcomed the proposal;

In the year 1849 they authorized the Government of Madras to permit Captain Elliot to complete his magnetic survey by connecting the Indian magnetic observatories with the instru-

[1] Wm. Thos. Blanford (1832–1905); CIE.; *DIB.*; *Who Was Who.* [2] DDn. 662 (148) to SG., 3-12-55. [3] ib. (149), to DSG., 1-5-56. [4] DDn. 46 (4), Oldham to Home Dept., 6-& 20-4-61. [5] *JASB.*, XXII, 1853 (229-79, with map facing p. 610); Wm. H. Purdon; FRGS.; PWD. Punjab; Dr. Fleming (1822–1901), FRCS.; *JASB.*, XXIII, 1854, *Geology of Punjab*; (651-77), *Salt Range* Theobald. [6] *IO Cat.* (632), *Magnetic Svy. of E. Archipelago*; *Phil Trans.* 1851; Elliot. [7] DDn. 546 (257), to FRS., 27-4-53.

ments he had previously had in use. The return of Captain Elliot to England in the year 1849, and his death soon after return to India, ... prevented his entering on this duty. ... The Court will instruct the Government of Madras...to carry it out as soon as the services of a competent officer are available. ... With reference to the proposed mission of two German travellers...for...exploring the Himalayan Range 'in behalf of a more complete knowledge of telluric magnetism and many other branches of terrestial physics', ... the East India Company regard all such missions with great satisfaction.

If the Government of India, they continued, had no officer available to carry on Captain Elliot's observations, his instruments could be placed at the disposal of one of the Schlagintweit brothers[1]. On the Surveyor General's assurance that he had no officer to spare the Directors authorised the grant to Adolf Schlagintweit of a personal remuneration...of rupees...six hundred per mensem from the date of...arrival in India, together with such travelling allowances as [may be] indispensably necessary. ... The instruments...will be supplied at the expense of the East India Company. ... You will be allowed £150 as passage money to India.

The Court observe that you allow four years for...the objects in view, and they accordingly...approve of the continuance of the arrangements...for that time, during the whole of which you will consider yourself under the orders of the Government of India[2].

They later agreed to make the same allowance of Rs. 600 p.m. and travelling allowance Rs. 150 p.m. to Hermann also, so long as he and Adolf covered separate routes. They were to work through the Surveyor General[3].

As regards the scientific objects of the expedition [writes Adolf], the magnetical survey and its connection with the excellent observations of Captain Elliot in the Eastern Archipelago will require...our most special attention. ... We shall both, my brother Herman and myself, be animated by the most ardent desire to do credit to the Royal Society. With the magnetical observations in different parts of India we propose...to unite—

A:—A regular series of observations on the meteorology and the physical geography of the country. ... We shall also...give our attention to the geography of India. ...

B:—I myself will...collect as complete a series as possible of observations on the geology of India and of the Himalaya. It will be very essential to ascertain the elevation of many important points by barometrical, or in part by trigonometrical observations, and to work out accurate sections...and geological maps. ... We shall...collect fossils for the accurate determination of the comparative ages of the different sedimentary strata.

He asked for help in the way of scientific instruments, maps, charts, and trigonometrical data and for authoritative books on the physical geography of India[4].

In due course three brothers, Hermann, Adolf, and Robert, reached Bombay on 26th October 1854, and travelled by two different land routes to Madras, reaching Calcutta by steamer on 6th March 1855. They brought out with them a "valuable set of instruments" lent by the Directors, which included Elliot's instruments which had been reconditioned in England[5].

From Calcutta Adolf and Robert travelled through Bengal to Kumaun, where they "went to the Thibetan frontier, after having reached in...the environs of Nanda Devi and Milum heights of 18,000 and 20,000 feet". After visiting the glaciers of the higher mountains. they dodged the frontier guards—like Moorcraft and Hearsay before them [II, 80]—and penetrated to Gartok, returning by Badrīnāth and Kedarnāth to reach Mussoorie in October.

Hermann, the eldest, visited Darjeeling accompanied by Lieutenant Adams [430], an Indian draughtsman, and a zoological assistant, and explored British Sikkim. He was refused permission to travel in Sikkim State or Nepāl [83, 85], though he managed two marches beyond the Nepāl border. He then visited the Khāsi and Jaintia Hills[6] and Upper Assam, visiting Dibrugarh, and returning to Calcutta in March 1856. His companion Adams and the draughtsman Abdul went on to Sadiya, and reported on coal and oil near the Nāga border[7] [448]. Hermann then travelled up country to Delhi, and reached Simla at the end of April 1856.

Adolf and Robert left Mussoorie in November 1855 and travelled together to Saugor in Central India, where they separated, Adolf travelling south to Mysore,

[1] DDn. 551 (211), CD. to RS., 18–5–53; *IO Cat.* (632), obsns. by Elliot.. [2] DDn. 546 (380), CD. to Adolf S. 10–5–54. [3] CD. to B., 19–9–55 (22–5). [4] DDn. 551 (219), 1854. [5] including 15 barometers, with two more lent by DSG. [6] DDn. 644 (274), Hermann to SG., 24–7–55. [7] Schlagintweit, I (20–1).

Madras, and Pondicherry, and then by sea to Calcutta to join Hermann in Simla in April 1856. Robert travelled in Central India before joining his brothers in Simla. All three then left Simla at the end of May, travelling by separate routes to Ladākh and the Karakoram, to meet at Srinagar in Kashmir in October. Here they sorted out their collections, which they sent down country by three caravans "at several days interval". They travelled down to Pindi by separate routes and Hermann then broke away to visit Nepāl for which he had at last received a permit;

I had quite an official reception, and a guard of sepoys constituting themselves my constant companions, partly in the capacity of guides, but more especially for keeping watch upon my operations. No restriction, however, was placed upon the use of my instruments, and I was allowed to take measurements, and also to draw, without let or hindrance [95][1].

He then sailed from Calcutta on 22nd April 1857 on his return to Europe.

In the meantime Robert travelled down the Indus valley to Karāchi, and then by land through Cutch and Gujarāt to Bombay, whence he sailed for Ceylon, and thence for Europe on 14th May.

From Pindi Adolf visited Peshāwar and the Khyber Pass, Kohāt, and Dera Ismail Khān, and then marched to Kāngra and Kulu, crossing the Bārālācha La on 31st May. Travelling through Ladākh he crossed the Karakoram to Kuenlun and then to Yārkand early in August. On his march to Kāshgar he had an unfriendly reception and was murdered. His fate remained unsolved for a long time.

The Schlagintweit brothers were not surveyors, and had little or no experience in the use of the barometers, chronometers, and other surveying instruments they carried. They were, however, accomplished artists and keen observers, and conscientious in recording and collecting evidence on the products and natural history of the countries they visited.

On their return to Germany Hermann and Robert published an account of their work under the title of *Results of a Scientific Mission to India and High Asia, 1854 to 1858*. There were 8 volumes of scientific observations, and an atlas containing 80 views and panoramas, and 20 to 30 maps and profiles[2]. Papers on their magnetic survey were published by the Asiatic Society in Calcutta[3]. Their large collections of geological and natural history specimens followed them to Germany[4]. The later collections made by Adolf were brought into Dehra Dūn by his Indian assistants, and were sorted out and packed for Europe by the survey staff[5].

In return for a representative collection of Indian maps which they took with them to Germany, and which was much admired by Baron Humboldt, they sent out a number of "splendid specimens of engraved maps" produced by the survey departments of Prussia, Austria, Switzerland, and Bavaria[6].

Unfortunately their contributions to Indian and Himālayan geography were of little value. The well-known cartographer Keith Johnston of Edinburgh could make nothing of their map of Central Asia, and sent Waugh a rough sketch

made "in a fruitless endeavour to reconcile the positions given by the Schlagintweit's with those of former observers. ... There are two positions of Lake Issikhul from the Russians, the latest much further west than the others, but still far short of the position given by the Schlagintweit's. Lake Srikul is 2° west of Wood's position; Bokharah nearly 2° 30′, and Tashkend upwards of 4°. If the Aral were to recede in the same proportion it would of course merge in the Caspian[7].

Waugh consulted John Walker, who found their positions "north and north-west of the Hindoo Koosh...much too far to the westward. ... If I were engaged upon a map of those countries...I should not pay any attention to them"[8]. At Waugh's suggestion Montgomerie was asked to report on their work in the regions of Ladākh as compared with that of the Kashmir Survey. He found that

the only portions of geographical value are the itinerary distances of their 8 or 9 marches to the north-east of the Karakoram Pass, and of the circuit made thereabouts as far as Russia. The marches...are, in fact, the only portion that is in any way new to British surveyors and

[1] Schlagintweit, I (29). [2] OBO. Lib., B-e, 32 (a-d); *IO Cat.* (74-7). [3] *JASB.*, XXV, 1856 (1-30; 105-33; 554-69); XXVI (208-16). [4] Schlagintweit (7-10). [5] DDn. 648 (376), DO., 6-6-59. [6] DDn. 715 (449), Herman to DSG., 23-6-58. [7] DDn. 6 (182) Johnston to Waugh, 21-1-62. [8] ib., 5-2-62.

explorers. Their chronometrical longitudes have proved to be of but little value, the usual precautions...having been neglected.

Leh...has proved to be no less than 19′ 43″, or say 19 miles, in defect of the G.T.S. value [of latitude]. This difference seems to be due in part to an error in their calculation...amounting to 7 miles, but still more due to their employing for their chronometer a large gaining rate, whereas...the said chronometer at all other times...had...a losing rate. ...

Their longitude of Leh depends almost entirely on a single altitude of the sun taken at Simla with a very small theodolite...at a considerable distance from the prime vertical. Still further uncertainty in their longitude...is involved by their omission to take sufficiently precise observations on their first arrival at Leh, whereby the uncertainty in rate of chronometer during 68...days carriage over very rough ground was unnecessarily introduced.

At Srinager...time observations are taken on two days, shewing a discrepancy...of no less than 27″ in about 24 hours. ... Longitudes of places in Ladak and Little Tibet...differ from the G.T.S. values...by amounts varying from 20 minutes in defect to 14 minutes in excess. Their latitudes shew differences up to 6 minutes. ...

With regard to the position of places in Gurhwal, Kumaon, and Gnari Khorsum, as well as in Ladak, ... I recommend that the values given by Captain Strachey be retained, as experience has proved them to be...wonderfully accurate [187]. ... The longitudes given by the Schlaginweit's in these regions, being all affected by a westerly bias, cannot be safely adopted[1].

In a further note he analyses the results given by the Schlagintweit's chronometer values for longitude, commenting that they

have perhaps had but little experience in the use of chronometers. ... Had the Schlagintweit's consulted standard works as to the determination of longitude, they would have seen how objectionable it is considered to use chronometers to determine small differences of longitude by a long journey in a meridional direction, such as their's from Simla to Leh.

He also pointed out their mistake in giving the name Ibi Gamin to the well-known Garhwāl peak Kāmet [87].

Hermann had pressed the name Gaurisankar for peak XV, or Mount Everest, which he claimed to have seen both from Sikkim and from a hill near Kāthmāndu, but it was doubtful whether he had identified the peak correctly, and it was later proved quite clearly that this name did not apply [95].

[1] DDn. 353 (68), Montgomerie to SRS., 28–7–62.

CHAPTER XI

INSTRUMENTS

THEODOLITES — *Three-foot — Two-foot — 15 and 18-inch — Small* — BASE-LINE EQUIPMENT — LEVELS *& Staves* — PERAMBULATORS — CARE & CUSTODY — *Workshop & Depot.*

THE theodolites which Everest brought out in 1830 were made by Troughton & Simms :—one 3-ft. and two 18-inch, read by micrometers [IV, 140–1]—and a number of small theodolites, from 5 to 12 inches, read by vernier.

To meet the requirements of his seven parties[1] he had a number of old instruments re-conditioned or re-assembled from derelicts. The principal of these was Lambton's 36-inch theodolite by Cary, which was most successfully reconstructed by Henry Barrow in time to be used on the Great Arc in company with that by Troughton & Simms [IV, 39, 142]. There were four 18-inch, three by Cary [IV, 143], and three 15-inch, one of which was with the Bombay party [IV, 144–5].

By the time Waugh took over charge, several of these instruments were no longer fit for first-class work, and it was only by constant exchange between one party and another—and sometimes even by keeping one field party working with a small instrument on its approximate series, whilst principal observations were proceeding in a neighbouring party—that work was kept going[2] [152].

The following were the "large theodolites" used between 1833 and 1862[3];

Maker	Azimuth Circle	Designation	History
Troughton & Simms ..	34-inch	TS. 3-ft.	1836–41, Gt. Arc; 1845–7, NE. Longl.; 1848–53, Gt. Longl.; 1856–60, Gt. Indus; 1860–3, Sutlej.
Barrow, from Cary [150]. ..	36-inch	Barrow 3-ft.	1802–25, Lambton & Everest; 1836–41, Gt. Arc; 1845–59, NE. Longl.; 1853–4, Chach base; 1856–7, Jogi-Tila 1865–6, Gt. Arc.
Mohsin Husain, design by Waugh.	24-inch	Waugh No. 1	1846–7, Gurwāni; 1847–53, NW. Him. & Gt. Indus; 1855–63, Rahun & Gt. Indus.
,,	,,	Waugh No. 2	1850–1, NE. Longl.; 1853–5, Assam; 1849–52, NW. Him. NE. Longl.
Troughton & Simms ..	,,	TS. No. 1	1847–63, S. Mal & Coast.
,,	,,	TS. No. 2	1849–51, NE. Longl. & NW. Him.; 1854–7, Jogi Tila & Gt. Indus.
Barrow ..	,,	Barrow No. 1	1848–52, NE. Longl. & N. Parasnāth; 1854–62, Assam & NE. Frontier.
,,	,,	Barrow No. 2	1850–3, Hurilaong & Assam; 1858–61, Coast.
Troughton & Simms ..	18-inch	TS. 18/1	1833–38, Amua; 1841–4, Karara; 1844–5, Maluncha; 1845–8, Cal. Merdl.; 1848–9, Hurilaong; 1849–50, Bombay; 1850 to store.
,,	,,	TS. 18/2	1838–9, Amua; 1840–3, Budhon; 1843–5, Chendwar; 1845–8, s. Maluncha; 1849–50, Hurilaong; 1850–62, Bombay.
Mohsin Husain ..	,,	Sd. M. 18	1844–6, Karara & Gurwāni; discarded, 1846.
Cary [Mad. Obsy. III, 259] ..	18-inch	Cary 18(MO)	1837–9, Ranghir; 1844–5, Karara; broken up 1846.
,, [Lambton's] ..	,,	Cary 18(L)	1833–7, Ranghir; destroyed by fire, 1837 [IV, 65].
,, [Cheape's, IV, 137]	,,		1833–8, S. Parasnāth.
,, ...	15-inch	Cary 15	1842–7, Sub. Merdl. & NE., Longl.
Barrow, from Harris [III, 216]	,,	HB. 15	1832–46, Sub. Merdl.
Dollond	,,	D. 15	Bombay; withdrawn 1849.

[1] six in Bengal, one in Bombay. [2] *GTS.* II (appx. 15). [3] ib. ch. III (47–52); appx. 2 (11–76), by Hennessey.

By 1845, with the exception of the two 3-ft. and the two new 18-inch theodolites, the larger instruments were "worn out and utterly unfit for operations of a delicate nature", and authority was obtained for two 24-inch instruments to be made up by Mohsin Husain in Calcutta, and four others to be constructed in England by Troughton & Simms, and Henry Barrow [IV, 417–49, V, 155].

After 1841 the two 3-ft. theodolites had been deposited at the Agra arsenal for safe keeping [162], and when Logan started work in 1845 on the North-East Longitudinal series, he was given Barrow's 36-inch and surrendered his 18-inch to Hill for the Coast series, which wrote the Surveyor General,

is the best of the class at my disposal, and when employed with skill and delicacy is capable of producing superior work. ... It will be necessary to replace it with one of the great theodolites at present in store at Agra. ... The carriage of a great theodolite is, however, more expensive than that of an 18-inch instrument. ... Mr. Logan will therefore be obliged to hire about 20 extra carriers, ... about Rs. 100 per mensem. ... His operations will be considerably accelerated by the use of the great theodolite, as half the number of observations taken with that instrument will surpass in value the full number taken with an 18-inch theodolite[1]. ...

You can have either of these [3 ft.] instruments which you like best, but if you express no preference I shall send you Barrow's, because it is more difficult to use than the other, and you understand its peculiarities. The other will then be available for other purposes, and I could issue it with more confidence to a less skilful person than yourself[2].

Troughton & Simms 3-ft. went to Walker on the move of the Maluncha party to the eastern end of the N.E. Longitudinal, and accompanied Renny to the Great Longitudinal in 1848.

On the extension of triangulation to the north-west the Surveyor General was anxious that the two main longitudinal chains should be of the highest standard of accuracy [34], but hesitated to send either of the great theodolites into the rough hills on the northern line ;

The Great Arc is the main axis on which the whole survey rests. From thence emanate the several longitudinal series at distances sufficiently apart to afford adequate verification to the subordinate meridional series depending on them. The longitudinal series themselves can only safely be extended to a certain distance and then require to be checked by measured bases ; ... if...carried on with inferior instrumental means...as was...the Calcutta Longitudinal [III, 264 ; IV, 58], ...much subsequent embarrassment may be expected. ...

The North-West series should be carried on with the best instrumental means that the world can produce, and...it would undoubtedly be desirable to employ on it one of the large 3-foot theodolites formerly used on the Great Arc, but...I have reluctantly come to the opinion that the great 3-foot theodolites are not adapted to service in such rugged mountains. ...

To enable an instrument of that class to be transported in such a region with any chance of safety it would be indispensable to cut roads from 5 to 6 feet broad from station to station.

He proposed, therefore, to send the first of the two new 24-inch theodolites made up in the Calcutta workshop which was already giving good service with Du Vernet on the Gurwāni series [34, 152–3] ;

Four others by the best makers are daily expected from England and another is being fitted up...in Calcutta, ... but I doubt whether any will surpass the instrument now in use with Captain Du Vernet, the results given by which...justify the opinion that in skilful hands it is capable of producing work hardly—if at all—inferior to that executed with the great theodolites. ... The new 2-ft. theodolite is equally as portable as the 18-inch instrument formerly in use with Captain Du Vernet which...was conveyed without difficulty in the mountains of Kumaun with only a little cutting here and there, and...when fitted up for carriage after the manner of a *jampan* [430]...may be safely carried from station to station [34][3].

All six of these 24-inch theodolites were brought into use as they became available, and after various adjustments and improvements gave first-class results, and were far more portable and convenient than the three-foot instruments. None, however, gave better results than this first one issued to Du Vernet [152–5].

The 18-inch and smaller instruments were confined to the subordinate series in Bengal, and to the Bombay and Kashmir triangulation [156–8, 221–2].

[1] DDn. 499 (128), SG. to Mil. Dept., 22–8–45. [2] DDn. 496 (91), SG. to Logan, 24–9–45. [3] DDn. 462 (100–8), 524 (49), SG. to Mil. Dept., 12–2–47 (paras. 11–13).

Technical reports on all the large theodolites will be found in Vol. I, of Waugh's Manuscripts, as well as in Hennessey's detailed account [148 n.3]. It is of interest to note that Barrow's 36-inch weighed 1,011 lbs.—TS. 3-ft. 1,051 lbs.—whilst Waugh's 24-inch No. 1 weighed only 620 lbs.

THREE-FOOT THEODOLITES

BARROW'S 36-inch was built up from Lambton's great theodolite which had been originally constructed by William Cary on Ramsden's design. It reached Madras in September 1802 and was used by Lambton and his assistants, and then by Everest till 1825 [II, 241, 253 ; III, 258–9]. After Everest's return in 1830 he had it entirely reconstructed by Barrow—"hardly any portion of the old fabrick remained"—some parts were adapted from "old musket barrels"—an entirely new azimuth circle was cast, and divided by hand by Barrow. Everest considered this renovated instrument gave as good results as the new 34-inch by Troughton & Simms [IV, 142][1].

It was regularly used on the Great Arc between 1836 and 1841, and then by Logan on the N.E. Longitudinal, but not taken on his move to the north-west in 1850. It was used by Montgomerie on the Chach base-line and by Tennant on the Jogi-Tila series during season 1856–7[2]. In 1855 the Surveyor General reported "the graduations...worn and nearly effaced"[3], but it was brought out for the last time to be used during season 1865–6 on the extra triangles added to stiffen the Great Arc round Meerut [IV, 83 ; pl. 5][4]. This grand old theodolite now stands in the Survey Museum, Dehra Dūn [IV, 142 n.2 ; pl. 6].

TROUGHTON & SIMMS 34-inch, or 3-ft., theodolite[5] reached India in 1830, and was first brought into use at Dehra Dūn in 1835 and, after some minor adjustments, continued on the Great Arc for the next six years [IV, 141]. After five years in store, it was brought out again in 1846 for use by Reginald Walker to whom Waugh gave detailed instructions[6] ;

> There is no observatory tent. ... Latterly we became luxurious and had 9-ft. tents, of which dimension I have ordered one to be constructed for your use. ...
>
> I have prepared for your guidance detailed instructions regarding the unpacking, use, and repacking, ... in which paper I have noted all...peculiarities, and given such hints as are the results of long experience. ... Mr. Logan...will draw up a similar paper for the other theodolite, so that the experience acquired by long practice may not be altogether lost. ...
>
> The box containing the body of the instrument is 3½ feet square, and the bamboos are about 14 feet long. On the line of march it is usual to apply 12 bearers at a time, 3 at each end of each pole. ... The space occupied by the party, and their weight, renders it very doubtful whether they could safely pass up winding stairs of less breadth than 6 or 6½ feet. ... Mr. Logan carries the instrument on its sliding board, but this plan is hardly safe, especially as it is heavier than Barrow's [*sup*][7].

It was overhauled at Dehra Dūn before being sent with Renny to the Great Longitudinal, Waugh reporting that,

> notwithstanding the...wear and tear to which it has been subjected during several years of constant work, it was found in excellent condition, with the exception of the friction roller apparatus which receives the axis. The rollers were found much worn and I have replaced them by new ones constructed on a different principle. ... For this design I am indebted to Captain Strange, who turned the rollers in masterly style with his own hands[8].

He writes to Strange who had taken over from Renny ;

> Captain Renny has reported that the great theodolite is in beautiful working condition, and that he is greatly indebted to your assistance for remedying certain defects which existed on his first receiving the instrument, ... though of a trivial character[9].

Strange carried out various other small alterations while the instrument was in his hands, and reported before handing over to Tennant four years later ;

[1] Markham (199); GTS., II (5) appx. 2 (33–7). [2] *GTS.* IV ; *Syn.*, V (xxiv - G). [3] DDn. 592 (343), 30–10–55 ; 594 (361), 6–10–60. [4] *GR Trig. 1865–6 & Syn.* II (i–xi). [5] *Roorkee Papers* (pl. lix). [6] v. Waugh MSS., vol. I. [7] DDn. 498 (77), 29–8–46. [8] DDn. 462 (265–307), SG. to Mil. Dept. 15–1–49. [9] DDn. 493 (225), 8–9–49.

The great theodolite continues in excellent...order, although one symptom of decay—probably the first that has ever manifested itself—appeared this season in the wearing away of the clamp screws of the horizontal circle. These screws are improperly of brass, and it is wonderful that they have lasted so long. ... The accident...occurred near Kurrachee and I was able to obtain new screws from the arsenal there.

The new micrometer heads made by me...were completed during last recess. ... As a proof of the permanence of the adjustments of this admirable instrument...during the five years that I have used it, the horizontal micrometers have never needed to be rectified[1].

From 1853 to 1856 it was with Tennant on the Great Indus series and was given a thorough overhaul by Mohsin Husain at Karāchi early in 1855. From 1856 it was transferred to the northern section but was not used for work on the right bank of the river where there was risk of frontier raids, TS. 24-inch No. 2, being kept for that purpose [47]. During the mutiny period it was kept safely under military custody. In 1859 Basevi had a new teak stand made and it then continued in regular use until returned to store in 1873, still in excellent working order. It had been used at 516 principal stations[2].

In 1916 it was presented to the Victoria Memorial Hall in Calcutta. It was reconditioned by the Mathematical Instrument Office in 1937, and on return was enclosed in a glass case with Lambton's old zenith sector [IV, 141].

STRANGE'S 36-inch theodolite. In 1855 Waugh drew up general specifications for a new 36-inch theodolite that should replace Barrow's, that was now shewing signs of age [150]. He circulated his proposals to his more experienced officers, and asked Strange to work out a detailed design ;

My object is to bring to bear all the varied experience of this department. ... We have frequently discussed the subject together. ... My own opinion inclines to the conclusion that for a portable geodetical instrument...to be used in very difficult hills and mountain tracts a horizontal circle of 30 inches diameter, and vertical of 21 inches, with a 30-inch telescope, would combine sufficient power in a more portable form than a 36-inch instrument can do.

Both the great theodolites now with the department have been carried over equally... difficult tracts, but...the weight of those theodolites is...as great as can be safely carried, whilst parts of the proposed design will add greatly to the weight. ... You are at liberty to alter the dimensions, though I am sure you would abandon the 36-inch size with reluctance[3].

Strange was not to be hurried, and writes nearly three years later whilst on leave in Ootacamund that he had designed almost every part

in minute detail three or four times already. ... New ideas have constantly presented themselves...and an alteration in one feature generally entails a change in many others. ... Though ...the design has been in my hands nearly three years, ... in addition to the ordinary duties of conducting a Series [East Coast], I have effected alterations...in a large theodolite [TS. 24-inch No. 1], which...were...executed by me personally. ... Loss of time...has arisen from the state of my health, which for a long time rendered mental application undesirable[4].

On rejoining from leave he left his original drawings to be copied in the Chief Engineer's office at Madras, hesitating to risk the sea journey with but the original set. To reminders from the Surveyor General he explained that both originals and traces had been mislaid and had not reached him till November 1859. They were awaiting his final touches. In August 1860 he handed the drawings over to the Deputy Surveyor General at Calcutta, together with about 60 pages of ms. specifications which he asked to be lithographed.

On leaving India in November 1860 he took the original papers to England and handed them over to Troughton & Simms, who were commissioned to put the work in hand. He introduced further modifications as work proceeded including the use of a new alloy of aluminium for certain parts. Though of the same diameter as Barrow's instrument, 36-inch, it was more substantial ; several special appliances were added, and when packed for travelling it occupied five cases of a total weight of 2,053 lbs.[5], though only 1076½ unpacked [150].

In 1872 it was inspected by Walker, now Superintendent Trigonometrical Surveys, who was on leave in England, and he writes to Strange ;

[1] DDn. 618 (53), 9-7-53. [2] *GTS.* II, appx. 2. [3] DDn. 592 (268), SG. to Strange, 8-10-55. [4] DDn. 697 (88), 10-7-58. [5] *GTS.*, II (56).

I have long been convinced that the great theodolite is far too cumbrous, and too complicated for employment in field operations, and this opinion is shared by Clarke[1] and by all the officers of my Department who have seen it. ... Weight...about 2,000 lbs....or more than double the weight of Troughton & Simm's 36-inch [actually 34"] theodolite, which I have always considered to be the maximum weight which we can afford to carry about. ...

–I left a memo...recommending that the instrument should be disposed of in this country and made over to any observatory or scientific institution[2].

It was, however, sent out to India, and used by Tennant and Campbell in December 1874 during observations for the transit of Venus. Campbell described it as "a magnificent instrument, elaborated in its details to an unusual degree...[but] not convenient for astronomical work. But I envy the surveyor who may have to use this...for triangulation if...in moderately level country"[3].

But it was of no use for triangulation in India, and in 1882 was transferred to the Royal Observatory at Cape Town, where it was put to good service by Dr. Gill[4].

TWO-FOOT THEODOLITES

WAUGH'S 24-inch. Pending the receipt of the four 24-inch theodolites ordered from England at the end of 1845 [149], Waugh made up two others from unserviceable instruments and derelict parts. After discussing possibilities with Mohsin Husain, he told the Deputy Surveyor General that

there are two spare azimuth circles of 24-inch diameter...which I am desirous should be fitted up as theodolites. ... Those...are beautiful specimens of Troughton & Simms' hand graduation, and originally formed part of the astronomical circles, ... but were found to be too slight for the superincumbent weight, and my predecessor was obliged to replace them by cast iron circles of greater strength [IV, 132]. They are fully competent to support the lighter vertical apparatus usually attached to new theodolites. ...

Among the instruments sent to Calcutta...there are two altitude and azimuth circles, quite unserviceable in their present condition, but admirably suited to furnish a light and efficient vertical apparatus to each of the spare azimuth circles[5].

He indicated other instruments, including a "Bombay theodolite which is a condemned instrument lying useless in the workshop [IV, 144–5]", from which microscopes and other parts might be cannibalized. He had explained his design to the Mathematical Instrument Maker, who thoroughly comprehends the principle. ... Almost all the parts...are ready prepared to hand and merely require to be adapted and put together. I am in hopes that one instrument at least will be out of hand in 4 months and...in the field early next season. This will save me a vast deal of embarrassment...because such is the present deficiency...that I am obliged to move theodolites from one series to another [148][6].

He reported later to Government that,

to furnish the projected instrument with a proper vertical apparatus, I availed myself of an 18-inch altitude and azimuth circle by Cary, also lying useless in the store at Agra. This... was of a pattern belonging to bygone times, top-heavy. ... The only use ever made of it for many years was...for...observing simultaneous vertical angles for the...Great Arc in the plains [IV, 41]. ... Thus a modernized theodolite of considerable power was to be constructed out of old materials lying useless in store, for, although the several parts were each sufficiently perfect in themselves, still, from the faulty design of former days, a new combination was required to enable them to serve any purpose of real utility[7].

Mohsin Husain had his first instrument ready within six months and,

notwithstanding this great rapidity, it was pronounced by Colonel Waugh to be a splendid specimen of its kind. ... It is still [1874] thoroughly efficient and doing duty in the field. Besides other desirable qualities, its comparatively small weight [618 lb.] recommended it for employment in difficult ground, so that it was selected for the triangulation of the North-West Himalaya series in 1847 [34, 149][8].

Before leaving the workshop it was given a rigorous test by Hill. It reached Allahābād in October 1846, and after a final trial by Waugh himself it was issued to

[1] Alex. Ross Clarke (1828–1914), OS.; *Who Was Who*. [2] Eur. Letters, I (95), 20–1–72. [3] *GR. Trig.*, 1871–5 (56). [4] Gill (xliii-iv). [5] Cary 18 (MO) [148] & Troughton, 15. [6] DDn. 473 (72–6), SG. to DSG. 4–2–46. [7] DDn. 462 (263–307), 15–1–49. [8] *GTS.* II, appx., 2 (15–6).

Du Vernet on the Gurwāni series and taken by him to the N.W. Himālaya. Waugh made further slight alterations at Dehra Dūn to make the rotation of the axis "perfectly smooth and glib. ... I was assisted by Captain Strange, ... recently appointed. ... This accomplished and talented officer is a very skilful practical mechanic, and took an active share in the construction"[1].

Renny-Tailyour used it for his first two stations in October 1850 [21], and then passed it to Logan for his principal triangles to Attock, Kālābāgh, and the Rahun series. This most successful instrument was still in service in 1874, and had given more work, from 337 stations, than any of the large theodolites excepting Troughton & Simms 3-ft[2].

Waugh's second theodolite was next put in hand using the second of Troughton's azimuth circles, and "the vertical apparatus...from an ancient 15-inch altitude and azimuth circle by Troughton". It was completed just as rapidly as the first, and was tested by Thuillier in May 1847 ;

The azimuth and vertical circles and the glasses of the telescope are by English makers, as also are the levels. The rest of the instrument, including the seven microscopes, has been made entirely by Syed Mohsin. My observatory was pitched on the Esplanade at Calcutta, nearly opposite to the Sudder Board Office[3].

After further test by Logan, it was first used by Renny-Tailyour season 1850–1, for the connection of the N.E. Longitudinal series to the Great Arc [21, 149] and in 1853 was transferred to the Assam longitudinal series [30].

No. 2 is decidedly inferior to No. 1, but is a respectable instrument. Both have been extensively employed...and are the most generally serviceable...of the principal theodolites of this survey. Their weights are materially less than...other theodolites...of the same...diameter[4]. In 1916, No. 1 was presented to the Victoria Memorial Hall in Calcutta, whilst No. 2 has found a home in the Survey Museum at Dehra Dūn[5].

TWO-FOOT THEODOLITES FROM ENGLAND. The four 24-inch theodolites ordered in July 1845 reached Calcutta by separate ships early in 1848. Two were constructed by Troughton & Simms, and two by Henry Barrow who had been Everest's Mathematical Instrument Maker from 1830 to 1839. "Each maker's construction differs so widely from the other that they have no resemblance"[6].

They had all been constructed with three fixed microscopes to read a revolving azimuth circle. Waugh had this changed on each instrument in turn to five equidistant flying microscopes reading to a fixed limb [116]. He also changed the clamps, and had other alterations made as minor defects came to notice. On the whole the two by Troughton & Simms gave the better results, but they all gave excellent service for the next forty years. TS. No. 1 was selected by Hill for the Coast Series but was much criticised both by Clarkson and Strange on various counts, most of which were rectified by Strange or Mohsin.

The Surveyor General writes to Simms in August 1850 ;

Your 24-inch theodolites have satisfied our utmost expectations. The graduation surpasses even your former chef d'œuvres. ... I regret, however, that I did not specify 5 microscopes instead of 3. If you think we could...apply them now, I would indent for two more... for each instrument. ... The tightness of the transit axis between the Y's...prevents the telescope describing true verticals ; ... we have applied the remedy described in the enclosed. ... I shall be glad to learn your opinion of the 2nd design there given, for which I am indebted to my assistant Captain Strange[7].

Peyton reports that after taking over charge he found that the axis

occasionally betrayed a wobbling motion when moved in azimuth. I then deemed it necessary to lubricate the axis...as it had not undergone this operation since its arrival in India, ... about four years, and found a decided improvement...after the operation[8].

Waugh commented that Clarkson had in August 1850 taken

the...theodolite to the Mathematical Instrument Maker to put in thorough order, and I should have anticipated that he would have taken...that opportunity to lubricate the axis. ... The instrument was exposed to the terrible hurricane of May 1850 [25], during which the observatory tent came down. Mr. Clarkson reported that the theodolite had escaped injury. ...

[1] DDn. 462 (265–397), SG. to Mil. Dept., 15–1–49. [2] *GTS.*, II (50, 56). [3] DDn. 507 (27), DSG. to SG., 11–5–47. [4] *GTS.*, II (56). [5] *Sry. Notes*, 1–8–1916. [6] DDn. 65 (14) SG. to Lane, 28–9–58. [7] DDn. 543 (57), 31–8–50. [8] DDn. 599 (199), 17–7–52.

These hurricanes are always preceded for some hours by premonitory signs, and I would advise you by no means to allow the theodolite to be exposed again to risk[1].

When Strange was posted to charge of the Coast Series, Waugh specially asked him to report fully on this theodolite, comparing its performance with that of the sister instrument [*inf*]. He asked Thuillier to allow Mohsin Husain to make such improvements as Strange might recommend ;

Extensive alterations may be required. Ramsden's axis does not act satisfactorily, and never will. The question, however, is complicated by the fact that with our system of observing, which is intended to cause the cancellation of all instrumental errors, the final results ...are really very superior [116]. ... Major Strange's mechanical talents are of a high order... so that I have every confidence in his design being accordant with sound principles. ...

There is now in the workshop one of Barrow's 24-inch theodolites undergoing alteration, but that will be urgently required to replace the other Simms, preparatory to its conversion[2].

Strange asked that workmen should be sent down from the Calcutta workshop to carry out various alterations under his own supervision at Cuttack. The Surveyor General agreed ;

Nothing short of an entire change in the principle of the axis will enable the 24-inch theodolite to act satisfactorily. ... Notwithstanding the extensive alterations which were made to the sister instrument last season, it appears to be in no great degree...improved in result, while in some respects...it is even more unsatisfactory...than before. ... The circle is superbly graduated, ... but...if the dissatisfaction...is entirely referable to the axis, nothing short of a new axis can remove it. ... This is the case with the 24-inch theodolite you are now using[3].

Four men with a lathe joined Strange at Cuttack on 16th June 1856, and he put in hand the changes to the axis with the help of drawings from Tennant. He also fitted new "achromatic object glasses" to the micrometers and found them "vastly superior to the simple lenses". These had been sent out by Troughton & Simms for the change from "the flying limb to the flying microscope principle ".

Another trouble that Strange sought to put right was a periodical deflection of the wooden triped which affected the horizontal readings according to the hour-angle of the sun ; "I propose adopting your suggestion of baking. oiling, and painting the legs and head, and...if iron braces be then substituted for the present wooden ones, it would probably cause no further anxiety[4]".

The instrument had later to be entirely stripped and overhauled by Mohsin Husain in Calcutta after advice by Tennant, for, writes Waugh,

the instrument, before it was altered by Major Strange, gave satisfactory results, but it did not level well nor hold to its reading on account of the horizontal clamps being unsuitable to the axis, which had much torsion. Major Strange undertook to cure these defects. ... After his alterations the instrument gave unsatisfactory results[5].

TROUGHTON & SIMMS' 24-inch No. 2 was issued in 1854 to James Walker for the Jogi-Tila series. During 1853 it had been thoroughly overhauled at Mussoorie under the immediate supervision of the Surveyor General—two additional microscopes applied—spiral springs removed from the horizontal clamps which were made rigid—and several other minor alterations[6]. Further alterations made by Strange and Cribble did not entirely remove the defects though the theodolite was used successfully on the Great Indus series [138]. When Walker took charge of the Trigonometrical Survey he had a "clamping circle fitted, ... as the radii of the azimuthal circle are thin and flexible, and yield...to tangential pressure applied at the circumference of the circle"[7].

In his final report Waugh told Government that these two 24-inch theodolites had given satisfaction, ... though from a peculiarity of construction in the axis and clamps they were troublesome to use, owing to a difficulty in levelling, and want of permanence in the readings arising from the clamps being unsuited. ... These defects had been greatly complained against by the observers, though the angular measurements were satisfactory. ...

The sister instrument had been employed...on the Jogi-Tila Series. ... With the assistance of Mr. Cribble...and Major Strange alterations were effected under my personal supervision which greatly improved the manipulation. ...

[1] DDn. 595 (166), 10-3-52. [2] DDn 665 (188), 24-3-56. [3] DDn. 691 (50), SG. to Strange, 26-3-56. [4] DDn. 698 (138), Strange to SG., 1-7-56. [5] DDn. 701 (45), Tennant to SG., 7-1-59 ; (93), SG. to Govt., 3-9-60. [6] *GTS.*, IV ; *Syn.* VI (xi-xv—G). [7] *GTS.*, II (56).

Major Strange wished to effect similar improvements to the Coast Series instrument. ... During his absence the charge of the party devolved on Mr. Clarkson. ... In his hands the instrument after Major Strange's alterations gave unsatisfactory results...[and] was sent to the Mathematical Instrument Workshops. ... A new design was...made under my instructions, and the necessary renovation now being carried out...will, I hope, prove successful[1].

BARROW'S 24-inch No. 1 was used by Peyton and Nicolson on the N.E. Longitudinal and Parasnāth series. When it was first sent into the field the Surveyor General directed Peyton to put it through "a thorough examination and trial", and to "submit a report on its merits and peculiarities". He was to spend more than a week making repeated observations on various combinations of zeros.

The sister theodolite...having arrived here with all the levels broken, I should not be surprised to learn that your levels also were liable to break if much exposed in hot weather. ... You have spare levels. ... These...should be carefully packed in cotton. ... It will be one of your earliest duties to take the runs of your levels[2] [63, 117].

No. 1 remained with Nicolson for the start of the Assam Series, and after Waugh's inspection of Du Vernet in January 1853, it was withdrawn to be "refitted ready for any emergency" with the five flying microscopes. "If the Mir Sahib has carried out my designs successfully...the instrument will be one of the finest in the world and little, if at all, inferior to the great 36-inch theodolites"[3].

During its withdrawal up till January 1855, Nicolson had been working with Waugh's No. 2, but on the return of Barrow No. 1, he was allowed to choose between the two, and after a series of experimental observations "he elected to work in future with Barrow's No. 1 which remained with the Assam party for many years after it had swung south to work along the North-East Frontier.

BARROW No. 2 was issued to the Hurilaong series in February 1851, after Renny had drawn up detailed instructions for its handling[4]. On Armstrong's move to the Punjab it was transferred to Nicolson for season 1852–3, and then sent into store at Calcutta. After its conversion to the "flying microscope" design, it was issued to the Coast series to replace TS. No. 1. After Waugh had left India, it was seriously injured by the fall of a tower and was sent to England for repair by Troughton & Simms, where both circles were re-divided "so that it was practically converted into a new instrument"[5].

Barrow No. 1 is now an exhibit in the Survey Museum at Dehra Dūn.

18- AND 15-INCH THEODOLITES

During Everest's time the four parties employed on the subordinate meridional series—increased to six after completion of the Great Arc—had been equipped with 18 and 15-inch theodolites, only two of which, the 18-inch by Troughton & Simms, were new instruments brought out by Everest [IV, 141–2; V, 148].

There was an 18-inch made up from derelict instruments by Mohsin Husain, a 15-inch by Harris that had been refitted by Barrow, and gave first-class results, and other very old instruments [IV, 142–3; V, 148]. It was to replace this old stock that Waugh obtained sanction for six new 24-inch theodolites, the first of which was taken into use in 1847 [153].

TS. 18, Nos. 1 and 2, were in constant use between 1832 and 1850, being transferred from one series to another as need arose. So far as it is possible to distinguish between them with the aid of Hennessey's record [148 n.3], No. 1 gave excellent results with Peyton on the Calcutta Meridional series after Shortrede had reported unfavourably on its performance with the Karara series. After one season with the Bombay party it was returned to store in 1850.

No. 2 was transferred to the Bombay party in 1850[6] and gave excellent results until replaced by Barrow 24-inch No. 2 in 1862 [54].

[1] DDn. 595 (361), SG.'s Report, 1859–60, 6–10–60. [2] DDn. 515 (166), 21–9–48. [3] DDn. 592 (176–8), 26–10–54. [4] Waugh MS., I, 3–9–50. [5] *GTS.* II (56); appx. 20; cf. I, appx. 2 (17–8). [6] DDn. 718 (81), SG. to Rivers, 26–2–50.

The 18-inch by Mohsin Husain had been allotted to Du Vernet for the North Connecting series, and was classed by Waugh as "little inferior to the Troughton & Simms theodolite with Mr. Logan, and vastly superior to all the other instruments in the Department". On the Karara series Du Vernet complained that the angles "were liable to peculiar errors". Waugh himself took a number of observations with it at Sora near Rae Bareli to put it to the test [11]; "the experiments...clearly shewed that the result of 24 angles taken in pairs at every 10° of the limb could not be depended on to 3".33 of the truth" but with certain changes of zero a mean could be obtained "to about half a second of the truth". This he

attributed to the peculiar manner in which the instrument was graduated, each 10° stroke of the graduation having been first laid off, and the remainder of the divisions interpolated. By this arrangement...the same error would most likely recur...at every 10° of the limb, consequently a system involving changes of zero by exact arcs of 10° would fail to eliminate the errors [115, 132].

He devised a system of changing zero that Du Vernet followed with "highly satisfactory results"[1]. On the close of the Gurwāni series and the receipt of the first 24-inch theodolite, the old 18-inch was "dismantled and expended".

In exchange for the TS. 18 No. 1 on the Karara series Shortrede was first given Cary's 18-inch MO. [148], and when that was found to be thoroughly out of order, he was given the Harris-Barrow 15-inch which proved successful [IV, 143 ; V, 148], and was taken on by Armstrong to the Gora series. When the Surveyor General inspected the party in the field during February 1846, he found it

very much out of order, the axis having become so extremely stiff that it could only be moved with two hands. An evil of this kind if allowed to continue would no doubt have vitiated all the work. ... Lieut. Garforth stated that the stiffness had been...felt for some time, and had gone on increasing, but that he did not feel himself competent to remedy the evil. ... I...lost no time in dismantling the instrument, cleaning the axis, and putting every part in good adjustment, ... and the instrument was afterwards found to work smooth and glib[2].

With my own hands [wrote Waugh], I cleaned and adjusted your instrument...and you lost the opportunity of learning practically how to adjust the instrument. You will, I hope, see the propriety of using it with extreme gentleness, and of packing it up carefully on all occasions with your own hands, so that it may have every chance of retaining its adjustments and not embarrass you with getting out of order[3].

At the close of the season he pointed out that the Harris-Barrow

has always born a very high character, ... and deservedly so, as you will perceive from the triangular errors of your series, all of which are highly satisfactory. ... I am thinking of giving the theodolite a new stand, with a triangle for shifting the zero and centring[4].

This old 15-inch was not, however, considered good enough for observation of principal angles when Armstrong took the Gora series to work along the N.E. Longitudinal [82]. He was to confine himself to the lay-out of the approximate series, and to secondary observations to the snow peaks. It was with this instrument, therefore, that Armstrong observed his peak (b), that proved later to be the highest in the world [17, 82].

Shortrede's 15-inch by Dollond gave good service on the Bombay side for many years to both Jacob and Rivers [IV, 145], but by 1847 it began to show obvious signs of wear, and its performance was hardly improved by Rivers' amateur repairs[5]. After the closing observations on the Khānpisura series at the end of 1848, it was withdrawn to store [54, 56].

SMALL THEODOLITES

Every party of the Great Trigonometrical Survey held a number of small theodolites for laying out the approximate series and for running secondary and minor triangulation. The main triangulation of topographical parties had also to be provided for. When fitting out Du Vernet's party for the North-West Himālaya

[1] DDn. 462 (21–51), to Mil. Dept., 19–8–46 (paras. 12–15). [2] ib. (para 29). [3] DDn. 491 (247–60), to Garforth, 12–9–45. [4] DDn. 495 (144–9), to Garforth, 18–5–46. [5] DDn. 518 (376), Rivers to SE., 1–12–48.

series, provision had to be made for the geographical survey of the mountain area, and the Surveyor General justified his special home indent ;

Experience teaches us that secondary triangulation executed with smaller instruments than 12-inch diameter are not satisfactory, but as the number of these are limited it will be very difficult to muster a suffcient number. ... As Mr. Logan's party will, however, be chiefly employed at the [Chach] base-line next season [43], I can...withdraw his 12-inch theodolite, and...equip Captain Du Vernet with 3 of that valuable class. ...

– To supply, however, the deficiency in other quarters, I...submit an indent...for 6 new instruments. In my specification...I have introduced certain alterations...calculated to improve them in point of accuracy. As Mr. Simms is celebrated as a maker of graduated instruments ...I would strongly recommend that the indent should be entrusted to him for execution[1].

He wrote privately to Simms, "having used for many years many of the chef-d'œuvres of your art" and asked him to provide the 12-inch theodolites with

a graduated scale for the level which regulates the vertical verniers, ... to shew 2″ or 3″, because in Colonel Everest's pattern [IV, 144]...the level cannot be practically adjusted. ... It is...indispensable to read off the level and apply a correction.

He further asked that the theodolites should be fitted with a complete vertical circle with 4 verniers instead of a 40° arc ; "our Asiatic dominions already extend to nearly 36° and our geographical explorations may extend further"[2].

He was short of instruments for the survey of the Jammu boundary [210] ;

Being limited strictly to the requirements of the Great Trigonometrical Survey, which has been confined...to 6 general parties and one in the Bombay Presidency, I am greatly perplexed to furnish Lieutenant Robinson with a proper outfit, more especially as two of our 12-inch theodolites were injured by the rebels in the Jaswan Doon [35, 162][3].

Robinson was furnished with "a 12-inch altitude and azimuth instrument... which I expect is the one used by Genl. Hodgson and Maj. Herbert in the survey of Sirmoor and Gurhwal"[4], purchased for the Department in 1822 [III, 216].

A 14-inch theodolite issued to Strange for secondary work had been used in the mountain operations. Some long series extending up to and beyond the snowy, range have been carried on with stations of great altitude, many reaching 17,000 and 18,000 [202–3]. The results of the verticals have proved most satisfactory. ... By my method of noting level readings and correcting for level error, the results become freed from this error[5] [159]. It was possibly this same or a sister instrument that was issued to Montgomerie for the Kashmir survey and used with such great success on the principal triangles from Jummoo to Ladākh [222].

In 1855, with Strange in charge of the offices at Dehra Dūn, Waugh drew up

for the general use of the Department the heads of a lecture for imparting a thorough systematic knowledge of the principles of vernier theodolites, ... so as to obtain accurate results in conformity with existing departmental rule and usage. Every 3rd class sub-assistant should be thoroughly master of these instruments before he is qualified for promotion. ... It is the duty of the senior officers of the Department...to impart this knowledge at as early a period as possible after an assistant joins [163][6].

He writes to Montgomerie in 1856 ;

A 14-inch theodolite is superior to any of the smaller size, and nothing less than this is fit for your principal series, nor for any branch series much exceeding 120 miles.

The 12-inch theodolite in good hands will no doubt accomplish very surprising results, as has been shewn by Lieutenant Nasmyth. ... In the meantime...these new 8-inch theodolites seem peculiarly well fitted to do good service in your operations. The complete vertical circle is a vast convenience, and the instrument can be carried by two men, or 3, giving a relief[7].

He thought the use of a 12-inch theodolite on ray-traces "verging on a waste of means" and it was a "dreadful waste to employ a 14-inch in katcha work". He writes to Strange regretting his issue of a new 7-inch theodolite

for approximate operations. This is in direct contravention of [my wishes]. ... It is with the greatest difficulty I can obtain an adequate supply. ... The new 7-inch theodolites are the best we have of their class, and we have very few of them. To use them except for real work is

[1] DDn. 524 (49), SG. to Mil. Dept., 12–2–47. [2] DDn. 513 (57), SG. to Simms, 31–8–50. [3] DDn. 542 (68), 4–9–50. [4] DDn. 561 (122–3), SG. to DSG., 16–7–50. [5] DDn. 709 (1), 26–7–52. [6] DDn. 592 (202), 26–6–55 ; Waugh MSS., II ; cf. Thuillier & Smyth, 3rd edn. appx., paper revised by Hennessey, Aug., 1859 (GEO. Lib. H–m–20) defines theodolite as identical with alt-azth. inst. [III, 216 n.5]. [7] DDn. 715 (121), 20–3–56.

waste of means. ... As far as mere selection of stations goes in a hilly country it is sufficient if the angles are true to 1 minute. ... A first-rate new theodolite is not necessary for approximate selection. ... It is sufficient that your approximate party should be equipped with a planetable, a first-rate hand telescope, and the worst or oldest theodolite available[1].

Waugh would indeed have been amazed at the high-class work carried out in these days by glass-arc theodolites of small diameter.

BASE-LINE EQUIPMENT [IV, 45–6]

The compensation bars and other base-line apparatus had been stored at Agra in 1841, and had to be reconditioned for the Sonakhoda base in 1847. The Surveyor General called Mohsin Husain up to Dinapore for this purpose.

Colonel Everest took the comparison microscopes to England [IV, 47–8]; therefore, new ones will be necessary. ... There are two pairs of spare microscopes in Calcutta. One of these might be used if fitted up with good well-ground axis and good levels. ... It will be necessary for you to bring up...the standard bar—the...six-inch scale—thermometers A and B—the spare thermometers of the standard bars—the two standard scales by Cary and Dollond[2].

For the Chach and Karāchi bases, he welcomed the assistance of Strange as "a good mechanical workman" but took the precaution of bringing Mohsin Husain round by sea to Karāchi for that measurement. The transport of the apparatus from one place to another was a serious operation—46 marches from Dehra Dūn to Chach, 1st October to the end of November—and a considerable party under charge of a senior assistant had to be provided. The four-month journey down to Karāchi, was made by bullock cart the whole way "without accident or injury" under Keelan's charge [43].

Strange describes the arrangements he made for the accommodation of all the gear during the rains. Obtaining loan of a barrack building 260 feet by 24, he had part of the floor raised two feet on which to pitch three of the bar tents;

I have placed the standard bar and bars A, B, C, in one of these tents; bars D, E, and H, and the microscopes ... in the second; and the boning instruments, the camel boxes, the registers, the barometers, and the lamps and heliotropes in the third tent. The other bar tents are packed on trestles between the 3 tents...and the blank wall. ...

The bars rest on their camels, and the standard bar on trestles, all duly cross-levelled as desired by you. I have removed the tangent screws and deposited them in their respective camel boxes as a precaution against rust. ...

I have appointed a guard of 5 burkandazes, 1 duffadar, and 8 callassies...to be on duty day and night. All the doors and windows are to be open from 6 to 8 a.m. daily for the sake of ventilating the building, and to enable the men...to watch for...white ants or rats[3].

He was given charge of all arrangements for the Karāchi measurement [44];

At the measurement of the Chuch base you have had an opportunity of becoming thoroughly acquainted with the apparatus, and learned its working, its advantages and defects. ... At previous base-lines its defects were fully apparent, and these it was clear could only be avoided by a new apparatus discarding the compensation principle, and retaining the microscopic power. ... The apparatus...is no doubt the best...hitherto invented.

As regards minor improvements suggested by Strange, continues Waugh,

the soundness of your mechanical views and...practical skill give me every confidence that such improvements...will prove eminently beneficial. ... I have accordingly ordered down the small workshop attached to my field office[4].

Before leaving India Waugh drew up precise accounts of the measurements at Chach and Karāchi[5] [44]. He had found at Chach, writes Markham, that,

as on former occasions, the length of the compensation bars was...not constant during a single hour of the day owing to the dissimilar radiating power in the brass and iron. The only available remedy was to compare them with the standard under circumstances exactly identical with those prevailing during the measurement [IV, 47, 51].

He concluded that Colby's compensation system was unsatisfactory, and

recommended that the Survey should be equipped with a new apparatus...free from all its

[1] DDn. 691 (94), 12–8–56. [2] DDn. 464 (169–70), 10–2–47. [3] DDn. 612 (60), 1–6–54. [4] DDn. 592 (49–52), 18–2–54. [5] submitted to Mil Dept.; DDn. 643 (214), 11–5–58; with memo. to DSG., 665 (438).

defects. ... The relative length of the bars changed according to some law independent of temperature. He would, ... discard the compensation principle and substitute simple iron bars ...coupled by a pair of microscopes revolving round an axis regulated by a level[1].

The compensation bars remained, however, the only means available for measuring the two last base-lines of the main trigonometrical framework—Vizagapatam, 1862—and Cape Comorin, 1868–9.

The 10-foot STANDARD BAR and 6-inch scale used by Waugh were those marked A brought out by Everest in 1830 [IV, 47–8]. In 1856 a STANDARD YARD arrived from England[2], and the following year a special room at Dehra Dūn was set aside where subsidiary standards could be laid off or compared by microscope[3], as when making up staves for levelling operations [160].

LEVELS & STAVES

Accounts are given elsewhere of improvised tide-gauges [71–2], and of the difficulties of borrowing such self-registering gauges as had already reached India [72–4]. When ordered to make connection between the principal triangulation and sea-level on the Gulf of Cambay, Rivers had the utmost difficulty not only in getting the promise of a tide-gauge from Bombay, but even in finding a spirit level. Even the Deputy Surveyor General was unable to find a level for him in Calcutta, and with the difficulty of finding a suitable site, the Cambay enterprise was eventually abandoned [57, 72–4].

When Walker started on spirit-levelling to test his vertical angles on the Jogi-Tila series [75], he obtained from the Chief Engineer at Lahore two "very fine standard spirit-levels by Troughton & Simms...recently procured from England... for the Punjab Canal Department"[4] besides six sets of levelling staves. The levels had good telescopes, but were "so top-heavy that it was hopeless to level them perfectly. ... The values of the 'runs'...were therefore determined in order that corrections might be applied for dislevelment" [75][5].

For operations up the Indus valley, two instruments that had been specially fitted with particularly sensitive levels in Calcutta were lost on the sea voyage to Karāchi, and Walker borrowed "a very superior standard level from the officer in charge of the Baree Doab Canal", which gave him three instruments

incomparably superior in delicacy of level and in magnifying power to ordinary...instruments. ... We are yet unfortunate to have been prevented...from fitting them with still more delicate levels, cased in glass tubes to guard against sudden variations of temperature[6].

Before starting work he readjusted the levels, extending "the graduation towards the centre, ... because Mr. Carty...had often been compelled when the heat was very great to keep a wetted cloth over his level...to retain its ends in view".

As a fourth instrument was required to equip the two levelling parties, Walker asked Troughton & Simms to "construct a new improved standard level", which, owing to Simms' ill-health, did not reach India till 1860, too late for the second season. With his official indent Walker sent a photograph and detailed description ;

The telescope tube, instead of being cylindrical as usual, is rectangular, thereby greatly increasing its rigidity. ... The tube is surmounted by two levels, with...mirrors...to reflect... the bubbles to an observer...at the eye end. ... In work through a stiff clay soil...the movement of the observer from the eye-piece to a position facing the levels is sure to throw the bubble out of...position. ... Their ordinary charge for a standard level is £40 ; for this one they charged £55, which is very moderate[7].

The charge was accepted. This level, or one of the same pattern, is now in the museum at Dehra Dūn.

Walker took particular care in designing a suitable staff. Before the staves from the Canal Department could be used it was essential to determine their true

[1] Markham (111–2). [2] now in Svy. Museum, Dehra Dūn, with bar A. [3] *GTS.* IV., Sec. 2 ; DDn. 665 (340), & 711 (24); SG. to DSG. & Walker, 19– & 16–3–57. [4] one now in Svy. Museum, DDn. [5] *GTS.* IV & *Syn.* VI (XXI–G). [6] DDn. Comp., M-9/7, Walker to SG., 2–12–58. [7] DDn. 710 (323), Walker to SG., 8–9–60, v. Waugh MSS. II, vii ; spirit levels, Hennessey, 18–8–60.

length in terms of the survey unit. This was done by measuring a short base-line with the staves and connecting it with the triangulation. The error of the staff unit was found to be as much as half an inch in 10 feet [76][1].

For the Indus valley Walker drew up his own specification ;

> The most probable error being in reading, ... the precaution was taken of making up staves specially figured. ... They were painted and divided on both faces to feet, tenths, and hundredths, one having a white ground with black divisions numbered from 0 to 10, the other having a black ground with white divisons numbered from 5·55 to 15·55. ... The observer cannot be biased to repeat in the second reading a mistake which he may have made in the first. Any error in either reading is immediately shewn up. ...
>
> The unit of the...staves must be determined in terms of the 10-foot standard of the G.T. Survey. ... A portable metal bar on which the length of the standard bar has been laid off is taken with each party of levellers. The staves should be compared with it at least twice during the season. ... As the wood of the staves has a tendency to shrink, a partial separation from the brass at the ends may be caused. ... An exact foot should be taken off with a beam compass from any of the intermediate feet, all of which are defined by dots on brass pins let into the staff, and the spot should be marked...[to] indicate the true position of the zero[2].

Ten staves were put in hand by the Mathematical Instrument Maker at Calcutta in April 1857. They were made of teak with "graduations laid off from the Gilbert brass 40-inch standard" and compared with the new English standard yard[3]. They were sent round by sea to Karāchi and reached Walker in December 1858, just in time for his first season's work.

The staves were shod with brass and the soles smooth and flat, and special care was taken to set them exactly perpendicular by means of

> plummets let into their sides and visible through glass doors. ... Their summits are fitted with swivels to which stay ropes were attached. ... Hemispherical brass brads were driven into the wooden pins marking out the line...to present a point for the staves to rest on, that they might be revolved freely, and each face presented in succession to the surveyor[4].

Walker's pattern of stave continued in use by the Department for the next forty years. A specimen is on exhibit in the Survey Museum.

PERAMBULATORS

Perambulators were still used on the Great Trigonometrical Survey, being particularly valuable for lay-out of the approximate series by ray-trace [103–4]. Surveyors were also encouraged to lay down the position of villages and prominent objects by theodolite bearings and perambulator measurement [119].

Everest had been proud to design his own improved pattern, striving for "strength, durability, and accuracy", and setting the cyclometer to read miles and decimals instead of furlongs and yards [IV, 145–7 ; pl. 7]. The Ordnance Department made up a number of these in iron instead of wood which Waugh did not like, fearing that,

> when constructed of iron, ... subject to so much jar or vibration, ... the delicate parts of the works would be liable to injury, and the pins to work loose. ... It is questionable whether the wooden perambulator would not be cheaper, more effective, and easier repaired. The light wheel is very handy certainly in open ground, but Colonel Everest intentionally made the wheel...so extremely heavy in order that it might be impossible for a man to carry it, whereby it must from sheer necessity be rolled along...over and through every obstruction. ... When time is...of importance, a Surveyor is frequently induced to gallop forward to the next station, ... and the perambulator is thus left to the man wheeling it[5].

Renny agreed ;

> I used one of the iron perambulators in my ray-tracing for...the Maluncha meridional series immediately north of the Ganges, and...the rigidity of all its parts occasioned so great a jar that the linch-pins and the screw attaching the dial to the axle were constantly loosened and liable to drop out unless secured by string or other elastic material[6].

[1] *GTS.* IV & *Syn.*, VI (xxi - G). [2] DDn. 722 (425–6), Walker to SG., *GTS.*, XIX & DSG., 24–2–57 (36). [3] DDn. 665 (340), SG. to DSG., 19–3–7 & 663 (109), DSG. to SG., 14–4–57. [4] DDn. 594 (325), note by Walker, 25–9–60. [5] DDn. 491 (59–60), 25–6–44. [6] DDn. 454 (153–4), Renny to SG., 8–7–44.

Both Logan and Garforth disliked the iron perambulator, Logan writing ;

At the commencement of the approximate operations...a wooden and an iron perambulator were used together, and so long as the surface of the country was even, they continued to give regular results, the distance shewn by the iron exceeding that shewn by the wooden perambulator, but as soon as the country became irregular, the difference increased, and by the time the iron perambulator had been rolled about 40 miles it had become quite unserviceable. ... I much prefer the wooden ones. ... I am...returning both the iron ones into store[1].

Garforth found that the tire became indented between the spokes,

consequently the ends of the spokes had begun to draw out from the tire. It was now tried to restore the circle by beating with a hammer, but at the end of each day's march the deviation had increased, ... and on leaving the metalled road and rolling the wheel over the uneven surface of rice fields, the ends of the spokes left the tire and a wheel no longer remained[2].

Waugh thought he could improve considerably on Everest's wooden pattern, though it was undoubtedly hard wearing,

the wheel being a miniature gun-carriage wheel. Their weight is usually objected to, and no doubt is inconvenient in hilly countries, but two men can always work it, and for a hard day's work across country two men are necessary for every perambulator. ... The weight and momentum of the wheel is advantageous in...pushing through grass, reeds, or crops.

The chief objections...are two-fold. One arises from its size which brings the dial so near the ground as to expose it to injury from stumps and stubble. This is...obviated by...a strong guard plate in front of the dial. The other has reference to the size of the dial, which is very elegantly designed, but is so small that the teeth of the dial plates have not depth enough to lay firm hold of the screw. ... I much prefer dial plates similar to the Madras wheel, which are strong and can be easily read. ...

I have...had my attention very strongly directed to the subject of perambulators. ... In the level plains of the Gangetic valley we have been obliged to resort to their use for the purpose of choosing stations...rapidly. ... There are...no less than 24 perambulators in constant use. ... I have lately constructed a wheel-barrow perambulator, 4 ft. in diameter, which runs extremely light, and possesses several other advantages. ... I am also about to construct a wheel somewhat smaller than the Madras one, which I think will prove more handy[3].

For his improved pattern Waugh ordered that the axle should be at least 1·2 inches diameter. Everest's was too slight, and his 12-mile dial useless, and

the 6-mile...little better. The thread of the endless screw should be deep, and the teeth of the dial strong and deep, otherwise they are liable to slip, and the indications of the dial cannot be depended on. All the new 6-inch dials are therefore to be made twice the diameter of Col. Everest's pattern, and the teeth...twice the present dimensions, so that they may have a firm hold on each other. ... The 4 feet perambulator, 10 mile dial:—when any new ones are made, the scantling of the wood...should be increased quarter of an inch each way.

All these new perambulators to have my name engraved[4].

Extensive trials were made on his two patterns, 10 and 20 mile ;

The results were not deemed satisfactory as they fell short of that extreme degree of perfection which I aimed at. This failure has not arisen from any error in...general design, but from slight defects in the construction. ... These perambulators were all made in my field office at Dinapore in...1847...during my absence on survey in the Sikkim mountains. ...

The 20-mile perambulator has given every satisfaction. It is light and handy, and yet sufficiently strong. I have worked some of these implements over upwards of 1,500 miles of very rough country. ... They have shown no deterioration. ... I am dissatisfied with the workmanship of...the dials. ... As soon as I reach my field office, I shall be able to make the contemplated alteration. ... I hope to be able to despatch the pattern in 6 weeks or 2 months[5].

The finished model was despatched a few months later ;

This perambulator has been much approved...on account of its correctness, strength, and handiness, but in offering it as a pattern I by no means wish to disparage Col. Everest's small perambulator, which is also a very handy, strong, and correct instrument, and it is difficult to decide which is best. The only defects that his pattern possesses are those which can easily be altered ; 1st., the axle is too weak and frequently breaks ; 2ndly., the diameter of the dial being small, the scale of graduations is also small, and the teeth deficient in strength. ...

The advantages my pattern possesses are, ... 1st. The wheel being larger, the power of propulsion is more advantageously applied...to keep the wheel steady. ... 2nd. The graduations

[1] DDn. 499 (154–7), 5–6–46. [2] DDn. 494 (257–8) 29–9–46. [3] DDn. 464 (108–10), SG. to Mil. Bd., 6–10–46. [4] DDn. 492 (43–5), memo. by SG., 1847 ? [5] DDn. 543 (34), SG. to Mil. Bd., 28–3–50.

on the dial are large and distinct. ... 3rdly. The teeth are strong to guard against wear and tear. 4thly. Although the scale of the lower plate extends to 5 miles, the perambulator will measure up to 20 miles by means of a small counting wheel. ...

The large perambulator, ... usually denominated the Madras pattern, for measuring miles, furlōngs, and yards, is so generally approved that I would hesitate to recommend its being dispensed with. Nevertheless it is only fit for roads and smooth level ground. ... It is not susceptible of being made...strong and enduring...without rendering it more unwieldy[1].

The new Waugh perambulator is described in the *Manual of Surveying*[2]. Diameter of the wheel 3 ft. 5·1588 inches; "the wheel is constructed...with a stout iron tire put on hot". A scraper was attached to prevent accumulation of mud that would increase the diameter and give measurements too small. It was one of Waugh's essential provisions that the measurements of every perambulator should be tested against one or two sides of a principal triangle.

CARE & CUSTODY

From 1839 the instrument workshop and depot at Calcutta had been under charge of an Engineer officer responsible to the Military Board, first Alexander Boileau, and then at the end of 1843, Henry Goodwyn [163–4]. From May 1844, Wroughton was appointed Superintendent in his capacity of Deputy Surveyor General [348], with the Mathematical Instrument Maker, Saiyad Mohsin Husain, responsible for repairs and construction [164, 357–8].

In September 1845, Mohsin Husain was summoned up-country to accompany the Surveyor General to Agra and take over the equipment and instruments deposited there in the ordnance magazine during 1841 and 1842. These were moved down to Calcutta, except the great theodolites, the base-line apparatus, and other articles required in the field, which were delivered at the field office at Allahābād [341]. About the same time the instruments from Boileau's magnetic observatory at Simla were deposited at the Agra magazine [IV, 118].

Survey instruments were precious, not so much on account of their intrinsic worth, but because of the very great difficulty of replacing them, and the loss of professional time in the event of loss or damage. The Surveyor General writes to Rivers whose 15-inch theodolite had been looted, though recovered soon after with the loss of the indispensable eyepiece [56];

A mishap of this character has never occurred on this side of India, where it is the practice to post a sentry over the instruments, and they are always accompanied by a guard on the line of march. On dark nights, or in localities of bad repute, we usually multiply the guards...by making the kalashis or carriers stand sentry. These precautions are indispensable in a country like India where glittering metallic substances are supposed to be very valuable. ...

As to the danger of travelling on dark nights—...our invariable practice in hot weather on account of persons carrying great weights under a hot sun being very liable to "coup de soleil"—flambeaux of course accompany the theodolite on such occasions[3].

In 1849 Du Vernet's party was in the field in the Hoshiārpur District when there was a rising of the Sikhs, and Charles Olliver with his triangulation detachment and baggage was captured [35]. He was rescued after a few days, but all his private baggage was lost, and of the public instruments under his charge, although many were recovered, some were found so much injured as to be unserviceable. ...

Among the recovered articles is a 12-inch theodolite, ... once a beautiful instrument, and though at present unserviceable by reason of the distortion of its graduated limb, still many parts are in good order. ... As the defective parts...can be most economically repaired by the original maker...I would recommend its being sent home for that purpose. ... A new azimuth circle will be absolutely necessary [35 n.5].

At the same time I forward another 12-inch theodolite which has become unserviceable from the divisions being effaced by wear. This also I...recommend may be sent to Messrs. Troughton & Simms to be re-graduated and put in good condition. ...

[1] DDn. 561 (239), SG. to Mil. Bd., 19-7-50. [2] Thuillier & Smyth, 2nd. edn. (88–91). [3] DDn. 325 (537–41), 14-6-48.

I am not induced to advise this course from any dissatisfaction with the...Instrument Maker's Department. ... Every species of repair work...can be well executed in Calcutta, excepting the graduation of the higher class of circles. Mr. Simms surpasses all artists in the world in this difficult branch of his profession, and his newly invented dividing engine is so excellent a contrivance that the re-graduation of these theodolites will not only be executed by him with greater precision than in Calcutta, but also more economically[1].

Garforth's natural reluctance to dismantle his large theodolite in the field has been noticed in contrast to the confidence with which the Surveyor General tackled the job himself [156]. Renny gave his instrument constant personal care and attention, and in his rules for care of theodolites he notes that

the best oil for lubrication is that derived from the fat of fowls, ducks, or geese. It should be prepared in winter. The fat should be put into a clean, dry, bottle, and corked. The bottle should be boiled taking care that neither water nor steam obtain access to the fat, as aqueous particles in the oil would...rust any articles to which it might be applied. After boiling, the oil should be run off from the dross. ... The oil should then be put into a long narrow bottle such as an eau-de-cologne bottle, which should be corked and hung in the sunshine. The pure oil will float on the surface, and any remaining...fibre or other dross will subside. After a few days rest the pure oil should be decanted, taking care not to shake up the dross[2].

Strange would never be defeated by any instrument ;

About a week before taking the field, an accident...threatened most untoward consequences. ... I have, besides the siderial chronometer, ...a solar chronometer...by Arnold & Dent. This chronometer one day stopped. On examining it I could find no injury, and...concluded it required cleaning and oiling. ... On taking it to pieces...I...rectified its defects.

Only two days after this, the siderial chronometer also stopped, and at a glance it was evident that one pivot of the balance wheel was broken. I therefore took it to pieces and found that the broken pivot was quite dry and covered with a fine red powder, which I conceived to have been rust...as the pivot and its hole were perfectly dry. I determined...to repair this damage, and after three days most anxious labour I was so fortunate as to succeed completely, the chronometer having since, apparently, kept as good a rate as formerly. ...

Had these two instruments failed me...they could not have been replaced in time to take star observations at all my appointed stations[3].

Du Vernet on the other hand was more like other men ;

The chronometer has not been in the hands of a watchmaker for nine or ten years, if not for a greater time. It stops and apparently requires cleaning. I have forwarded it to Captain Thuillier that it may undergo the necessary repairs[4].

Waugh rebuked Walker for not taking his instruments into recess quarters ;

Leaving out the question of risk of fire, damp, white ants, and rough usage, all of which being foreseen may be to a certain extent guarded against, ... there are thousands of casualties unforeseen which require the eye of a master to provide a remedy when they occur.

But the chief reason why a surveyor should have his tools always at head during the recess is this. They all require to be put in order, cleaned, lubricated, adjusted, wired perhaps, besides petty repairs—alterations in fitting of boxes—new cases when necessary—arrangements for transport—and hundreds of minor jobs too numerous to mention. ... Moreover the assistants require to be instructed in these parts of their duty, besides learning the use of the instruments which they cannot do unless the instruments are at hand[5] [157].

WORKSHOP & DEPOT

The workshop established at Calcutta in 1830 for the repair of the instruments of the Great Trigonometrical Survey had soon been flooded with work from all directions [IV, 125–7]. Barrow had built up a capable staff of skilled workmen, but after his departure the workshop passed from one charge to another and the workmen drifted away.

The business management and correspondence had been a heavy burden, first on De Penning the Chief Computer, and then on Bedford, Deputy Surveyor General, till the latter succeeded in passing the burden to an extra-departmental officer

[1] DDn. 462 (333–5), SG. to Mil. Dept., 19–7–49. [2] DDn. 369 (17), 26–11–49. [3] DDn. 594 (79), Strange to SG., 21–5–51. [4] DDn. 602 (165), to SG., 25–6–53. [5] DDn. 592 (197), SG. to Walker, 14–6–55.

responsible to the Military Board. Early in 1844 Goodwyn, now in charge, called attention to the pressure of work and the inadequacy of staff ;

There is not...a European artizan in Calcutta to whom the repairs and re-adjustment of surveying and philosophical instruments can be entrusted...[and] few men on the establishment who are capable of undertaking the finer...repairs of such instruments. ... The number of theodolites alone lately received through the arsenal from the Allahabad and Chunar magazines amount to about 108, exclusive of others from the Revenue Board, Surveyor General's Department, and other services[1]. The time...taken in repairs of these...cannot possibly be...under 3 years, whilst others will in the meantime be coming in[2].

He asked that about two-thirds of the work might be passed overseas to England. Waugh, who had just become Surveyor General, asked that the instruments be moved elsewhere as there was no room for them with his headquarter offices. The Military Board recounted the recent history of the workshop and asked Government to review the whole matter that it might be restored to an efficient state.

Mr. Gray held charge of the office until the 1st December 1839, when Captain...Boileau was appointed Superintendent. ... Capt. Goodwyn succeeded...on the 17th November 1843, and still retains the charge. But when this officer was appointed Garrison Engineer...the workshop establishment with all the numerous and valuable instruments and tools were removed into the Fort[3], and now, from want of...office room, suitable workshops and godown, ... the whole establishment is...almost disorganized, and scarcely working at all. ...

The conduct and management of the Mathematical Instrument Maker's establishment... has been entirely separated from the proper head of the establishment since Mr. Barrow left the Presidency, that gentleman, and subsequently Syed Mohsin, having charge of the important field branch immediately under the Surveyor General. ... Now that the Surveyor General is himself at Calcutta as well as Syed Mohsin, there seems to be no reason why the Mathematical Instrument Maker should not assume his full charge. ...

The establishment as at present constituted is wholly unequal to meet the calls made upon it. ... While there are at this moment 93 theodolites of various kinds requiring repairs, ... only 17 were repaired during the last year. ... And...no fewer than 110 theodolites are lying useless to the State. ... This great accumulation...has entailed...supplying a far greater number of serviceable *new* instruments than would have been necessary. ...

We beg to submit the following proposals. ... Syed Mohsin being unable to read or keep accounts cannot be recognized as the HEAD of the office.

1st. The establishment to be permanently attached to the Surveyor General's Department as...was orginally intended, but in consequence of the liability of the Surveyor General to be...for long periods absent from the Presidency, the actual executive charge...to be vested in the Deputy Surveyor General with an allowance of 100 rupees a month.

2ndly. Meer Syeed Mohsin to be Mathematical Instrument Maker.

3rdly. Offices, godowns, and workshops to be prepared...in the compound of the Board of Revenue Office, immediately adjoining the Surveyor General's office.

4thly. Mir Syeed be authorized to engage...an assistant at a suitable salary [358, 360].

5thly. ... Make some small increase to the permanent establishment, and...a considerable increase...of the contingent charges and temporary establishment. ...

6thly. All unserviceable instruments should be sold, ... and...a great number of the repairable instruments at once sent to England to be repaired[4].

Wroughton was thereupon appointed Superintendent of the Mathematical Instrument Maker's Department with Mohsin Husain in technical charge [348, 357]. The assistant engaged was an artillery bombadier named Cribble, who proved an excellent mechanic and valuable assistant, capable of taking charge on the numerous occasions when Mohsin Husain was called up country. In 1853 he was transferred to open an instrument depot at the Thomason Engineering College at Roorkee [166, 358]. Thuillier took over charge from Wroughton in 1847.

A year later the Surveyor General was still pressing for the sale of surplus stock, and for the issue to field units of serviceable instruments of earlier patterns ;

As soon as a new batch of instruments arrives ... no one will make use of the old with good grace, though they may be quite as trustworthy. ... This is human nature. ... The first batch are very excellent implements, yet I find it difficult to get parties to take them[5].

[1] The closing of rev. svys., NWP. and LP., largely accounted for this [IV, 229]. [2] DDn. 451 (91-2), Goodwyn to Mil. Bd., 8-1-44. [3] after SG.'s request of 13-1-44. [4] DDn. 451 (2), Mil. Bd. to Mil. Dept., 4-4-44 ; approved, Mil. Dept. 451 (91-4), 3-5-44. [5] DDn. 473 (89-96), SG. to DSG., 28-12-48.

Business continued to expand, and Thuillier's annual report of 1852–3 gave the total work performed by the manufacturing branch, exhibiting the number of instruments manufactured, repaired, examined, purchased, packed, and re-issued, together with a comparative statement of expenditure incurred, ... detailing the difference between the values of the instruments when received, and when issued after repair, ... shewing a balance in favour of the actual working of the department.

During the year under review...the business [has been] placed on a more extended footing by the addition of a General Depot for the safe custody and deposit of all mathematical and surveying instruments. .... The whole of the instruments heretofore existing in the arsenal of Fort William and the magazine at Allahabad have been transferred to my charge, and suitable premises allowed in Park Street, immediately opposite the Surveyor General's office. ...

The transfer of the instruments from the arsenal took place on the 31st of January last, whilst the contents of the Allahabad magazine were received on the 8th June last. ... The whole of these instruments being now under the Mathematical Instrument Maker's own eye, he is able to adapt them...to the peculiar wants...of individual branches of the Survey Department, the Department of Public Works, and other miscellaneous branches of the public service. ...

The whole of the stores being concentrated in one Department, indenting officers can obtain their wants in a much more satisfactory and speedy manner. ...

In the workshop the superior...skill of Mr. Cribble, the Assistant Mathematical Instrument Maker, and his superintendence over the...workmen, has been lost by his transfer to the Roorkee depot, ... having been struck off on the 21st January last. ... The Storekeeper, Syed Ismail, in addition to his office duties, makes himself useful...supervising the artificers [358].

The year's work included

new instruments...manufactured, 789—repaired and adjusted, 630—examined, cleaned, and adjusted, 381—purchased, 1,327—packed, 290—refused, 216.

Of instruments manufactured, the principal ones are ;

Bars, standard, steel, 6-ft., graduated.
Chains, iron, Gunter's and khusrah.
Framework for tracing glasses.
Heliotropes for G.T. Survey.
Levelling instruments converted from old theodolites.
Levelling staves.
Planetables, G.T.S. pattern.
Protractors, brass, electro-plated.
Rules, ebony, parallel.
Quadrants, rockets, for Ordnance Department.
Scales, brass, khusrah.
Screw press, for paper for S.G.O.
Theodolite stands, braced heads.

Repairs and adjustments. ... Some of the theodolites have been extensively altered, and converted from the old principles into good useful implements of the prevailing Everest's pattern [IV, 144], and other have had additional adjustments applied to allow for the greater wear and tear which the constant daily use, especially on Revenue Surveys, renders necessary. ...

The lithographic press repaired was an old wooden one transferred from the Government Press, ... and by altering the construction from scraper to roller principle, and adding other contrivances, a very old and worthless implement had been turned to good account [329].

Many of the lesser instruments for Revenue Surveys were purchased locally, these instruments being made much cheaper in the bazaar than could have been effected by this establishment, and having been demanded in such large quantities ; ... each instrument being passed and approved by the Mathematical Instrument Maker. ...

The total actual expenditure, exclusive of the purchase of new instruments, but with all other charges, both permanent and contingent, amounts to rupees 15,887-2-4. ... The estimated value of the work performed is 17,959-15-3, excluding those items purchased and issued. ... This, however, is irrespective of house-rent[1].

The workshop did much to facilitate printing of the postage stamps [329, 333] ;

For...printing an enormous quantity of postage stamps in the lithographic press attached to the Surveyor General's Office, and by the skill and energy of the Mathematical Instrument Maker, no less than 8 imperial size...presses were prepared in the course of a few months, which enabled the Department...to furnish...upwards of 40 millions of Queen's heads before the 1st of October last. These presses now form a most useful addition to the stock of the Lithographic Branch of the Surveyor General's Office, and...answer admirably for striking off the best description of lithographic work. ...

Extra artificers have been sanctioned, ... but as yet I have been unable to procure beyond a very few hands, the East Indian Railway Department having secured the services of all the best men in the town. ... The rapid increase of surveys in Pegu, Arracan, in the Punjab, and the N.W.P., together with the pressing requirements of the Department of Public Works

[1] DDn. 563 (112), Supt. MID. to Mil. Bd., 30-8-53.

now extending in a fourfold ratio all over the country, have caused an immense demand on the resources of the Department [299][1].

In his report for 1855–6 Thuillier noted that

the theodolites have occupied the most time in their reconstruction, and extensive alteration from old to new principles. The demands for perambulators and levelling staves have been immense, the former...being difficult and tedious to make [161–2]. Heliotropes and plane-tables and tripod stands for various instruments have likewise been much called for. ...

The sum of 10,156 rupees has been expended on the purchase of new instruments during the year. Many very excellent instruments have been thus obtained, but doubtless at a cost double of that of the English price, and the quantity in store is still at the lowest ebb. ... Every expedient has been used...to render the very old ones, many of which ought long since to have been condemned, fit for a temporary purpose, as the only way of making early compliance with most pressing...requisitions.

He pressed for increased clerical establishment;

Promptness in compliance with all calls, and...early disposal of all accounts and business, ... is an essential element. ... To provide for the early preparation of our annual and monthly statements, ... which under are existing circumstances are difficult and troublesome, and under the new system are peremptorily demanded by the Military Auditor General[2].

At the end of 1860 full control of the Department, both the instrument depot and workshop, was transferred from the Inspector-General of Ordnance & Magazines to the Deputy Surveyor General himself[3], and the first report under the new arrangement was submitted by the latter to the President of the Military Finance Department. After giving the history of the department from 1830, Thuillier explained that when the office was controlled by the Ordnance Department

all matters connected with the contingent expenses required the previous sanction of the Inspector General before the Military Auditor General would pass the bills.

The purchase of all instruments...to meet indents previously sanctioned by himself still required confirmation by the Inspector General. ... All indents and requisitions of every description required the Inspector General's countersignature. ... This all led to great delay and extra work which would now be saved by the transfer to the Deputy Surveyor General.

The control exercised over the workshop rests, in the first instance, with the Mathl. Inst. Maker, who is responsible for all the mechanical duties, the efficiency of his artificers, and for the quantity of work they daily perform. He acts entirely under the guidance and advice of the Superintendent, which is responsible for the administrative portion of the Department, and for the economical working. ...

The Superintendent, being non-residential, with other multifarious duties to attend to, can only exercise general supervision and check, but from his daily intercourse and inspection being at all time within easy access, the business proceeds...without hindrance. ...

The Superintendent is the most likely person to know how to regulate the demands.

He pointed out the difficulty of preparing a budget estimate. The Department was "liable to receive indents any day to the extent of several thousand rupees value". It had been "suddenly called upon to supply the newly raised Madras Revenue Surveys with instruments to the value of about Rs. 73,216-10-9. ... No foresight...can help...to...give a tolerably fair budget to the Finance Department"[4].

[1] DDn. 661 (49), Supt. MID. to Mil. Bd., 15–3–55. [2] DDn 662 (43) Supt. MID. to IO. Ordnance, 1–2–56. [3] GO. 1222 of 21–12–60. [4] MIO. Records, DSG. to Mil. FD., 28–11–61 ; v. supply of insts. for rev. svys. [298–9].

CHAPTER XII

TOPOGRAPHICAL SURVEYS: MADRAS ESTABLISHMENTS

GANJAM: *Goomsur, 1844–50* — ORISSA: *Cuttack Tributary Mahāls, 1850–3* — *Sambalpur, 1853–7* — *Orissa Coast, 1857–8* — *Tributary Mahāls & Khōnd Hills, 1858–61* — HYDERĀBĀD: *Morland & Brown, 1844–50* — *Mulheran, 1855–66* — NĪLGIRI HILLS, *1844–52.*

BY 1844 the Hyderābād Survey was the only one of Mackenzie's topographical parties still at work, and all the Madras districts except Ganjam had maps that were considered sufficient for the times. The coastal, well populated, areas of Ganjam had been surveyed by Charles Snell between 1830 and 1833 [III, 104], but there remained the wild hill tracts to the north-west where the tribes still indulged in ghastly human sacrifices [IV, 254, 456]. During the military operations of the late thirties "desultory route surveys" had been made through these hills by Thorold Hill and his assistants, effecting a tenuous extension of Snell's survey into the unknown, but with no regular triangulation [IV, 254–5].

Hill had taken sick leave to Europe in 1841 and work was not resumed until in 1843 the Madras Government appointed John Halpin, who had no previous experience of survey. During his first season Halpin surveyed a route through the Khōnd Hills into Patna State south of Sambalpur. He was then, placed under the orders of the Surveyor General, who directed him to concentrate on a network of triangulation and connected routes;

> With regard to the apprehended difficulty of carrying on a minor triangulation in the country, ... I am not aware that any physical obstacles can exist which perseverance and skill will not surmount, but there may be political and economical considerations. ...
>
> Desultory operations patched together, and attempted to be combined by astronomical observations made with inefficient portable instruments, are utterly valueless as surveys, and can only be considered as reconnaissance or rough exploration.
>
> All routes between extreme points should be direct and straight as possible. ... No attempt should be made to confine the route to paths or roads, because your object is to survey a country, and not measure roads. ... Minuteness of detail and the correct determination of the relative positions of distant points cannot be attained by one process. Such an attempt always leads to failure. The correct determination...of distant points is the primary...object. The details are subordinate thereto, and...cannot be allowed to influence the main work[1].

With two assistants[2] Halpin made his headquarters at Berhampur near the coast. He started triangulation north of Parlākimedi in November 1844, and in two months had completed 800 square miles of triangles filled in with planetable and route survey; further work was prevented by sickness[3]. Even smaller outturns followed during the next two seasons, and at the end of 1846 the Surveyor General brought Halpin up to Du Vernet's triangulation party for training [385].

On return to Ganjam Halpin was again grievously ill, and he died at Berhampur on 30th November 1848, after which the senior assistant, Robert Howard, took over charge and extended survey north of Palkonda. Work was still interrupted by sickness, and field season restricted to about four months[4] [168, 421, 463].

The Madras Government now nominated George Saxton for charge of the survey, but Waugh took the precaution of attaching him to the East Coast series under Hill for a full season's training. He was given charge at the end of March 1850;

[1] DDn. 491 (65–8), SG. to Halpin, 25–7–44. [2] Robt. Howard & Chas. Snell jr. [3] DDn. 462 (75), Report, 1844–5. [4] MBIO. 135 (4–6); 146 (27–31); ½-inch svys. Ganjam & Jeypore Agencies, 1844–7, 1849 *IO Cat.* (327, 413–4), most artistic shaded hills.

I am informed that you have acquired a knowledge of the principles of triangulation and computation—that you have made yourself acquainted with the use of the instruments and method of adjusting, cleaning, and taking care of them—that you have learned the office forms—that you have been inspired with a proper sense of accuracy and care, as well in the making of observations as in recording and reducing them—and finally that you have acquired some skill in the use of the plain table.

With this stock of acquired skill and knowledge, you will...take charge of your survey under very different circumstances from any officer who has been appointed for many years to the Madras topographical survey. ... I look to you to raise the character of the survey to higher standard, and introduce a systematic and energetic performance of duty. The system which has hitherto prevailed can no longer be tolerated. ...

As the whole tract of country is more or less unhealthy, and the season during which the party can be safely employed...is extremely limited, your enquiries should be directed to ascertain precisely the limiting dates, ... and...prevent any part of the favourable season being wasted. ... For the past two years the party under Mr. Howard have done little more than march out and return again to headquarters. ... I am prepared to make every allowance for the climate, and...to allow a slower rate of progress in a difficult country, but the moderate quantity of work must be executed by everybody. ... It will be your duty...to place on record... the number of times each individual has left the field at an early period, the length of time he has remained on the sick list, and your opinion of his bodily health, activity, and zeal[1].

Meanwhile Howard and his three assistants[2] were struggling to extend the survey by triangles, route survey, and planetable to the west of Bobbili;

We had first to thread a...jungly valley, through which we passed with great difficulty, where...the seeds of the fever...had been sown. ... As we ascended a high ghaut and came upon a fine open country, with low grassy hills, devoid of wood and studded with large villages, ... we were, with the apothecary and most of the camp followers, prostrated with fever. This happened in the early part of the month of January. Since then we continued so ill that I determined to quit the hills as a temporary measure. ... After...we were somewhat improved in health we...made a couple of marches up the valley when I and the other sub-assistants had a return of our fever, as also many of the camp followers, and out of an escort of eighteen sepoys fifteen men were on the sick report the second day.

The apothecary having proceeded for medical aid to Vizianagram, ... medicine brought with us being expended, I had no alternative left but to proceed also to Vizianagram[3].

The outturn for season 1849–50 had been confined to observation at six hill stations, planetable survey of 150 square miles, and a route survey of 50 miles[4].

CUTTACK TRIBUTARY MAHĀLS[5], 1850-3

Saxton took charge in May 1850, and after the rains moved the party north into Orissa as the Bengal Government had asked for survey of the Cuttack Tributary Mahāls [IV, 187; V, pl. I]. He broke out from a side of the South Parasnāth series [IV, 59-60], and worked south through the Nīlgiri Hills near Balasore. Within two months he and the greater part of his establishment were down with fever and retreated to Cuttack. Howard and King carried on alone for a few weeks longer. Only six angles of the first three triangles had been observed, and about 376 square miles surveyed by planetable on the ½-inch scale[6].

The Surveyor General was bitterly disappointed at this disastrous start, but felt reluctant to declare the undertaking impracticable. The hill tract...is covered with dense and unwholesome forest, ... with a sparse population of aboriginal tribes in the lowest stage of barbarism. The land, therefore, possesses apparently no intrinsic value...as a source of immediate revenue, and although it has sometimes formed the scene of local disturbances, the partial military operations for their suppression have been of small political importance.

Nevertheless, however apparently valueless the country may be, a map...is a desideratum, for a knowledge of...a country is the first step to improvement, and...must be based on good maps [t-page]. ... I could not...suggest the abandonment of the undertaking [176][7].

[1] DDn. 493 (285), 29-3-50. [2] King, Snell, Chatelier. [3] DDn. 593 (125), Howard to SG., 5-4-50. [4] *MRO.* (13/105); *IO Cal.* (414); MRIO. 136 (14), 1-inch srv. of Panchipenta *zamindari* 1849-50. [5] 18 in number, the largest being Mayūrbhanj, Keonjhar, Baud, and Denkānāl: *GR Topo. 1860-2* (27; appx. B, iv-xiii). [6] DDn. 593 (165-8), 27-3-51. [7] DDn. 549 (63), triennial report, 19-9-53 (para 208).

After consulting the civil authorities he concluded that Saxton had taken the field much too early and that the field season would have to be restricted to about four months, from early January to the end of April. He asked the Deputy Surveyor General to supervise Saxton's arrangements ;

Lieut. Saxton was instructed in his profession by Captain Hill, and his sub-assistants are practised planetable surveyors and draftsmen, but the nature of the climate is such...that the utmost difficulty must prevail. ... The history of the Survey Department shows more or less constant struggle against such difficulties, but in no case has a survey party suffered so constantly, and with such complete disorganization, as Lieut. Saxton's. He, however, entertains great hopes of success this year. I have supplied him with medical instructions... which have been followed with success on the trigonometrical and revenue surveys [458–60]. ... I trust that the work will progress satisfactorily.

This season the Coast series...is expected to complete the great triangulation up to Balasore and to make some advance from the Neilgherry Hills towards Cuttack [25–6]. When it arrives at Lieut. Saxton's ground...he will be relieved from the principal triangulation[1].

For season 1850–1 the party was reinforced by three sub-assistants from the Hyderābād survey [178, 421][2], and Saxton was directed to work triangulation southwards to complete the survey of the hill area and make continuous connection with the earlier revenue surveys [IV, 185–8]. The Surveyor General did not like the idea of a road survey between Cuttack and Sambalpur ;

On several occasions the Ganjam Survey party has detached a sub-assistant to accompany the Agent for Meriah sacrifices, but I am not aware that any results have been obtained in extension of our geographical knowledge of that interesting part of the country. ... Every surveyor so detached has deteriorated in professional qualifications, or fallen into lax habits of survey. ... All the route surveys executed by the Ganjam Survey, ... from the time of Captain Hill downwards, have been of the lowest order.

He insisted that if any assistant was detached for such route survey he should be specially trained to work with a 5- or 7-inch theodolite and a perambulator ;

The route should always originate from, and terminate at, objects whose geographical positions have been already ascertained, or which can be connected hereafter. The...traverse should be carefully recorded, the angles being repeated 4 times on 2 zeros, regulated by the magnetic bearings, and the distances determined by 3 perambulators reading differently, whose errors have been well ascertained[3] [288].

Government agreed that the road survey should await the completion of the topographical survey, and Saxton was directed to concentrate on the survey of the tributary states, to reach Angul and Nayāgarh as early as possible.

During 1851–2 triangulation extended south of Cuttack, with "13 principal and 43 secondary triangles, finally observed horizontally, with verticals of all principal and a few of the secondary stations". Triangulation was of good quality, observations being regularly taken to heliotropes. Computations kept up with the work and points were issued for ½-inch planetabling, with a few ready for the next season. This was the first really satisfactory season's work[4].

During season 1852–3, work covered Angul and Nayāgarh to the south[5], and the Civil Superintendent pressed for the early survey of the states of "Ooodeypoor, Jushpoor, and Sumbhalpoor" away to the north-west. The Surveyor General doubted the wisdom of extending to such a distance unless Saxton had an assistant able to take over charge in the event of his own sickness, and application was made to the Directors for the appointment of an officer assistant [171, 386]. Field work was restricted to three months, Saxton reporting in April 1853 ;

Messrs. Turnbull and King were...furnished with points of last season's work. ... Mr. Howard was detached into Ungool to select and clear principal and secondary stations. I proceeded with the rest of the party to the extremity of the proposed detail survey bordering on the Chilka Lake. ... I was able to lay down...sufficient...points and connect them with my principal triangulation. These were computed and the Nyagur Estate...given to Messrs. Summers and Snell for 1-inch survey. Mr. Leigh...was also given a board on ½-inch scale, and directed to survey the Runpur Estate. I then proceeded to complete the final angles on that side. ...

[1] DDn. 561 (197–8), SG. to DSG., 2–10–51. [2] Turnbull, Leigh, and Long ; DDn. 542 (270), Report 1850–1, 1–10–51. [3] DDn. 561 (203), SG. to DSG., 15–10–51. [4] MRIO. 58 (36–8, 53–5) ; DDn. 583 (247), Saxton to SG., 16–4–52 ; 549 (57), Report 1851–2 ; 1–10–52. [5] MRIO. ; 58 (25–6), 59 (11–13, 36–7).

On proceeding into Ungool I relieved Mr. Howard from his forward duties, and gave him a board on the ½-inch scale. ... I now advanced into a very wild and difficult country on the western side of Ungool, almost totally uninhabited, and bounded further west by an immense range of hills running from the Mahanuddy River in a north-westerly direction. On this range is my most advanced station, from which is a fine view of Boad and the neighbouring Khund Hills. ... After completing the azimuth observations I moved back completing the framework. ... I completed my final work and visited Mr. Turnbull and Mr. Leigh. My camp marched into Cuttack on the 31st March. ... The area surveyed is about 2,515 square miles, ... 565 are on 1-inch, and the remainder on ½-inch scale. The detached parties have nearly all suffered from fever, the season having been very unhealthy towards the end[1].

The season had indeed been a disastrous one, for Chatelier died in November and Turnbull in April, whilst Summers was laid up for most of the season.

In 1854 Saxton informed the Superintendent of the Tributary Mahāls that

since I assumed charge of this survey party four years ago I have triangulated over 1,200 square miles of the Tributary Mehals bordering on the three districts of Cuttack, and extending to the west beyond Sambalpore. 800 square miles of this area has been surveyed in detail, either on the ½, or full, inch... scale[2]. During the approaching field season the detail survey will be continued partly within the Cuttack mehals to complete the Athmullick and portions of the Boad estates. ... Operations...will be extended into...the sw. Frontier Agency, within which from Sambalpore towards Odeypore and Jushpore my triangulation will be carried on[3].

SAMBALPUR, 1853–7

During season 1853–4 triangulation was extended well to the west beyond Sambalpur, and planetabling into the Khōnd Hills. In addition to his own triangulation Saxton paid constant visits of inspection to each of his assistants, and at the request of the Civil Superintendent settled numerous boundary questions, for which purpose he had in 1852 been granted special powers [285];

Such duties are well placed in a Surveyor's hands. ... His decision has more weight...[with] the contending parties than...that of another without the knowledge of the country which the Surveyor must possess. ... The authority...is an advantage to the whole party. ...

About 30 miles to the west of Sumbulpur south of the Mahanuddy, there is a very extensive tableland of considerable height, ... formerly...affording shelter to rebels and marauders who were a terror to the surrounding low country. I propose the first thing next season to ascend this. I believe no European has yet been up to it, tho' there are a police station, a fort, and many villages on the top.

The sides of my triangles give an average of 20 miles. The heights of several of the hills are nearly 3,000 feet, and Raun especially is very difficult of ascent, requiring the hands as much as the feet in climbing over rocks with precipices on either side. I encamped as near the foot of the hill as possible...and started at daybreak, and yet my theodolite only reached the station at 4 p.m. They utterly failed in getting up my tent, tho' sent the previous day, and dinner had nothing commendable beyond our good appetites. Mr. G. Howard was cheerful...and he always shewed zeal and willingness for any amount of work[4].

The survey was specially appreciated for the opening up of the wilder parts of Orissa, and contributing to the suppression of the Merriah sacrifices [167], and the Civil Superintendent continued to press for the early completion of the Tributary Mahāls and deprecated extension to the west;

We have scarcely any knowledge of the unsurveyed portions of Mohurbunj and Keonjur, or of the Khund Hills of Boad, and a correct map of the latter is urgently required. The low country of Boad and the Atmullick Mehal have...been completed this year. There only remain, therefore, ... the Khund Hills, the mehal of Pal Lahara, and portions of Mohurbunj and Keonjur. Until these are finished, no map of this tract can be published[5].

The maps now came in for criticism by the Surveyor General, who had commented two years earlier that "the assistants...have not shone as draftsmen";

The drawing...on the larger scale is beautifully delineated, and the distinctive characteristics of dry cultivation and uncultivated lands well maintained. From the drawing I should con-

[1] DDn. 593 (335), 16–4–53. [2] MORIO. Misc. 32–O–53; 57 (1–3), 58, 11 (14, 18, 22–6, 37); 59 (10–13); *IO Cat.* (182–4, 327–8); trgn. charts, 1850–62, ib. (26, 53–4). [3] DDn. 548 (56), Sept. 1854. [4] DDn. 593 (453), Saxton to SG., 22–4–54. [5] DDn. 577 (18), to DSG., 2–4–55.

jecture the whole of the waste land to be open forest, but...it is difficult to indicate the varying character of forests without obliterating printing and hill features. ...

The hill drawing is peculiar. I can't say I admire it as a work of art. ... The crests and feet of hills are clearly defined by it, as well as the principal spurs or underfeatures, and the whole connected by a broad wash. The outlines...are thus merely indicated, and the forms not worked out in full effect by shading or stippling or contour touches. ...

This artificial style...appears...capable of guiding the engraver, and is perhaps better for that purpose than bad attempts at elaborate drawing. The objection to it is the monotony it produces, all hills being made nearly similar in character. ... A good artist can make a nearly perfect representation of nature, and not a mere artificial indication. ... I hope your party may...be able ere long to produce work of a higher standard [176, 291].

Mr. Howard's hill drawing is more elaborate, but...the features in some places do not appear to stand on a horizontal plane. This is a matter requiring great attention. ... Mr. Howard's printing is not very good. ...

On the large scale, 1 mile = 1 inch, no more of the minor features of hills is shewn than is sufficient for the geographical scale. ... It makes the hill drawing...look meagre. The ½-inch maps are on this account superior in appearance[1] [172, 291 ; pl. 9].

In a later report the Surveyor General found the work greatly improved both in quantity and quality, for which every credit is due to Captain Saxton, but, as neither himself nor Captain Depree are first-rate draftsmen, nor imbued with the highest talents for delineating ground, the greatest degree of excellence...cannot be expected. ... I am very anxious to add an officer of first-rate artistical talent to this party, ... but the exigencies of the service elsewhere prevent my making any redistribution[2].

For some time he had been urging the appointment of a young officer assistant who would be able to take charge of the party if ever Saxton's health should break down [169]. None of the sub-assistants was sufficiently qualified. It was, therefore, most welcome when a young Artillery officer, George Depree, a nephew of Saxton's with previous survey experience, joined the party in December 1854 with two new sub-assistants to replace casualties [386, 421]. Survey was extended westwards through the Mahāls and the party left Cuttack, reports Saxton, on Monday the 18th December. I arranged...to accompany Mr. King onto some convenient hill to test his points, some of which were mere intersections and open to doubt, and secondly to enquire into an important territorial dispute. ... I commenced triangulation in advance. ...

During the early part of the season my camp...continued healthy, but when our operations advanced to the north we entered a very wild uninhabited tract, with extensive ranges of hills and with valleys covered with rank vegetation. ... Fever became very prevalent. ... The number of cases was very startling, and I congratulated myself upon having got the assistance of a good medical officer. This is only the second time that my application for an Assistant Surgeon has been complied with. ... Most of the cases readily yielded to Dr. Shortt's treatment [464], but others were more severe. ... The moisture from the surrounding hills ...encourages a rank vegetation, from...which...I attribute the great amount of sickness. ...

Having started Lieut. Depree on his Sumbulpur survey[3], I proceeded myself to join Mr. [George] Howard's camp, and...see him at work. ... Mr. Snell returned from the field on account of sickness after completing about 324 instead of 360 square miles, and Mr. Long [60 sq. m.] was entirely crippled during a great part of the season. Mr. Howard senr. in addition to triangulation has completed about 275 sq. miles, and Mr. Howard junr. was given 256 which he has finished. ...

All the other sub-assistants, Messrs. Summers, Leigh, Claudius, and King, have done a full season's work of upwards of 360 sq. miles each, making in the aggregate 2,423 square miles surveyed on the planetables during the past season. This is all on the 1-inch scale, ...considerably more than has ever before been accomplished by this party, and...better also[4].

The triangulation in advance is more in accordance with the instructions conveyed with your remarks on my former operations. The principal triangles are all fairly symmetrical, The triangular errors are less[5].

Government asked that the surveyors should assist in exploring the mineral wealth of these wild hills, though the Surveyor General questioned the value of amateur efforts, and wanted nothing to interfere with the progress of the survey [142–3]; "No geologist can effect anything really accurate and valuable until maps

[1] DDn. 592 (106), SG. to Saxton, 7-9-54. [2] DDn. 652 (5), SG. to Mil. Dept., 6-10-60 (para. 68).
[3] MRIO. 88 (40–8). [4] MRIO. 57 (16); 58 (13), Sonpur & Boad. [5] DDn. 593 (609), 27-4-55.

are ready for him to base his researches on[1] [143]". He proposed the formation of a second party in order to accelerate progress;

"The tract to be surveyed is very extensive, including in the Bengal and Madras dominions —part of the Kutak Tributary Mehals—the South-West Frontier Agency—and all the hilly region up to Nagpore on the west—and all south down to the Hyderabad frontier and Karnool inclusive—all of which is more or less unsurveyed, or very imperfectly mapped; aggregating 36,893 square miles, including Sumbulpore. ...

I applied some time ago...for the appointment of an assistant. ... Lieutenant Depree has during the past season been practically initiated into the work. After next season he will be fit to take charge of a survey. ... Some augmentation...is necessary to prevent the retardation which the order will occasion—to combine an investigation of the mineral resources...with the topographical survey. ...

During the past three years Captain Saxton has had the advantage of part of the establishment of the Hyderabad survey. ... As the Hyderabad survey is now resumed [178], Captain Saxton will lose the services of the trained Hyderabad surveyors after the field season. My project is to form two parties out of Captain Saxton's, one under his immediate management, and the other under Lieutenant Depree's, and both to be under the general control of the senior. ... I propose that two parties shall [each] consist of 7 uncovenanted assistants and sub-assistants, and 2 native surveyors [421-2][2].

Pending approval to this expansion Saxton spent season 1855-6 completing the triangulation of the Tributary Mahāls, taking Depree with him with a view to his own early departure on furlough;

The great point I had before me was to secure a sufficient amount of triangulation in the new direction for the detail surveyors next season. With this object in view I kept my assistant with me, in order that in case of accident to myself he might be ready to continue this all-important duty. A very few more triangles to the north-east, to be executed by Lieut. Depree next season through Moharbunj and Chaibassa, will complete the Cuttack Tributary Mehals on the north side, and give a junction with the South Parasnath or Coast series[3].

In a letter home Depree tells of their preparations for the field [364];

We are to start from Cuttack on the 12th for our field work. ... Uncle George has only this morning received an order from the Surveyor General changing our route altogether so that instead of commencing work at a distance of 200 miles from Cuttack we shall begin at 50 miles or so, and work gradually towards Midnapore [176]. ... Though we shall be equally in wild country...we shall not be so far away from Cuttack, and we shall gradually diminish our distance from Midnapore. ... I trust we shall have a healthy...season. ... We shall of course keep our Xmas in the jungles, probably on the summit of some big hill. ...

P.S. You will find Keonjur in the map, ... the country we shall be surveying this year[4].

Observation at 25 stations gave sufficient area in advance for the next season, whilst the sub-assistants completed 2,330 square miles of one-inch survey[5].

In April 1856, with Saxton on furlough, the Surveyor General took advantage of the Coast Series recessing at Cuttack to place Strange in "general professional supervising control over the Ganjam Topographical Survey". Strange reported well on Depree but criticised the survey and mapping of hills [291, 386].

On the departure of Saxton on furlough, John Dyer was brought down from the Punjab and assumed charge of the second party on 6th May 1856, Depree taking over Saxton's party, and the two parties being thenceforward known as No. 1 and No. 2. Their total sanctioned strength was two officers in charge—one assistant, never appointed—14 civil assistants and sub-assistants, and four native surveyors or draughtsmen. Eight elephants were allowed for transport [*sup.*, 373, 421-2].

During season 1856-7, the planetablers of both parties were employed in the Tributary Mahāls, except for a few who accompanied Dyer to the neighbourhood of Sambalpur. Depree extended triangulation over 4,000 square miles in the comparatively flat country west of Balasore in readiness for the next season;

From the 22nd December to the 30th March I never halted for a single day, generally descending or ascending a hill, observing and making a march within the 16 hours, when not engaged observing throughout the day, or when not computing.

[1] DDn. 577 (22), SG. to DSG., 26-9-55. [2] DDn. 549 (150), SG. to Mil. Dept., 10-9-55. [3] DDn. 692 (1), Saxton to DSG., April 1856. [4] to his mother, Lucy Depree, 9-12-55; family letters. [5] Snell, Leigh, Claudius, King, Robt. & Geo. Howard, Richardson; MBIO. 57 (16-8).

The whole country presents a nearly level surface with no marked elevation, the only rises being dykes of irregularly shaped boulders of trap rock heaped with endless confusion, and not so high as the adjacent saul tree jungle, and running for many miles either north and south, or east and west, of an uniform height, and covered with jungle trees of the largest dimensions; thus the...country proved a great obstacle to a large symmetrical series being carried over it. ... I was gratified to find...a good connection with the Parasnath Series.

... Dense haze often "rendered every hill station totally invisible for several days". Sometimes observations could only "be carried on...early in the morning and late in the evening. The heat also...began to be oppressive".

On the 9th March a very heavy storm...delayed arrival of my tent until one o'clock A.M., and continued unabated during the whole of the next day. On the two succeeding days I... [observed] all the principal angles by taking advantage of...a gleam of sunshine whenever for a few moments it illuminated a heliotrope, every observation being obtained with a referring mark. [The haze returned]—My camp was...becoming more sickly, and my establishment worn out with the incessant labour, ... as well as disheartened by constant exposure to the burning sun, with no possibility of showing their own, or seeing my, signals[1].

He closed work on 30th of March and marched in to Cuttack;

My camp...since entering the low and more cultivated country suffered very generally from fever. They who had escaped throughout the season have during the march in been prostrated by the disease, and at the present time a large number of public, and all my private, servants are laid up. Dr. Gillies in medical charge was attacked on the 1st instant, and Mr. D. Atkinson the following day, they having been up to that time in the enjoyment of good health. I, who have for two years visited these pestilential jungles without in any way succumbing to the climate, was yesterday seized with a severe attack of the usual fever and ague which may perhaps cling to me for some time to come[2].

Disaster had also overtaken the planetablers and Snell and Richardson died during March and April. The Surveyor General suggested that a temporary transfer to Kashmir might be a tonic, but neither Depree nor any of his assistants were fit for the journey or for a strenuous summer season in the mountains [464–5].

In the meantime Dyer supervised a training camp of junior sub-assistants in the neighbourhood of Sambalpur, and after selecting the closing stations of Clarkson's longitudinal series [28], laid out a meridional series running north through Jashpur to the Calcutta Longitudinal series[3]. He observed at 28 hill stations, and his planetablers completed 1,560 square miles on the one-inch scale. "This proved an unhealthy season, but though he buried the apothecary...Mr. Dyer persevered and kept the field till 14th May", not returning to Cuttack till early June[4] [367].

ORISSA COAST, 1857–8

Saxton returned from furlough towards the end of September 1857, and resumed charge of No. 1 Party, Depree taking No. 2. Dyer's services were lent to the Commissioner for command of a local force raised from "armed paiks" from the service of "various rajahs in the Tributary Mahals. ... His local knowledge of Sumbulpur acquired during his survey is likely...to be of the very greatest service"[5]. He was later transferred to the uncovenanted Civil Service.

As it was considered unsafe to resume work towards Sambalpur where there had been trouble amongst the troops [482–4] both parties were diverted to carry out minor triangulation with a strip of planetable survey along the Orissa coast [28], Saxton working north-east from Puri towards False Point, and Depree south-west from the neighbourhood of Balasore. This survey was specially important for defining the coastline and it was intended to connect it by a longitudinal series running west from Point Palmyras[6] [176]. Saxton reports very slow progress;

I laid out the triangulation up to False Point before the end of February, and my whole... establishment has been ever since...endeavouring to clear rays. ... This work is still unfinished. Every member of my party has been at work all day. ...

[1] DDn. 594 (287), Depree to SG., 27–4–57. [2] DDn. 663 (112), Depree to SG., 8–4–57. [3] MRIO. 57 (10–18); 58 (39–46). [4] DDn. 336, Report 1856–7; 1-inch svys., 1855–7, *IO Cat.* (327). [5] DDn. 663 (330), Comnr. to Saxton, 18–12–57. [6] DDn. 665 (423), SG. to DSG., 18–3–58.

From Hurrichpore...generally, and about False Point in particular, the jungle is very dense...and though my stations occupy the highest spots, ... even to a greater sacrifice in symmetry than is desirable, a considerable amount of jungle-cutting was absolutely necessary, and the great difficulty has been in procuring labourers [477]. ...

From the peculiar circumstances in which the Rajah was placed the Collector refused to direct him to supply me with men, and without his orders no coolies could be had, and we were thus making scarcely any progress with very few workmen, the best of whom were my own camp bearers. Latterly...the Collector directed the zemindars...to supply men, and they came in plenty, ... but...sometimes...without any cutting instruments, and were sent back. ...

The jungle is intersected in all directions by large creeks, over which the coolies...have to be passed by boats. ... Nearly all the boats...are at this season employed by the salt makers. ... Every item of supplies has to be brought by boat, and every note of instruction[1].

In his annual report he notes that

nearly the whole of the two parties has been employed on...triangles extending between the Chilka Lake and Balasore for 180 miles. ... Most of the stations had been built by Mr. [Charles] Shelverton, but...some had to be entirely, and nearly all more or less, rebuilt. Our intention was to join work near False Point. ... My camp marched from Cuttack on the 28th January and reached the ground where Mr. Shelverton had discontinued work. ... We moved up the coast as rapidly as possible, but not clearing or building stations for which materials had to be prepared. By the end of February stations were selected to a few miles beyond False Point Lighthouse, a distance...of about 63 miles.

In considerable part the country was uninhabited jungles, under water at highest tides and intersected by formidable creeks and rivers only frequented by the salt-making Malungees. ... I was prohibited by the Collector from employing these men or their boats [477].

The whole party got into quarters about the 1st June after what has been to every member a very arduous season[2].

On the northern section, Depree closed work at the end of May ;

Mr. Ellison was directed to lay out the series, Mr. Chew to register, and Mr. MacVittie to survey with the planetable and perambulator the coast line and country bounding it to a distance of one mile inland on the scale of 2 inches = 1 mile. Mr. J. G. King, accompanied by Mr. F. Adams and an efficient native establishment, I directed...to the Damra River...to burn bricks for the station pillars, and then commence cutting rays and laying out the series. ... I observed my first angles...on the 8th February.

For the first 25 miles from Balasore work was impeded by "an almost unbroken line of villages and gardens, rendering it necessary to clear every diagonal ray, and causing much damage to private property". Further south there was difficulty in procuring labour for ray-clearing and supplies of food, but work continued

till the 25th May when, having failed to obtain further supplies of russud[3], I was compelled to desist, and started for Cuttack on the 26th, arriving on the 31st idem. I was unable to lay down the position of Point Palmyras as during the south-east monsoon no boat...could venture through the surf and rollers. The lighthouse has entirely disappeared, and the island appears simply as a small and low sandbank, scarcely visible at high tide. The mouths of the Damra and Mypurra could not be surveyed by the appliances at the disposal of a topographical party. There are very extensive sandbanks...which...are not laid down in the revenue survey map [IV, 187–9].

I have observed numerous temples, villages, and tree flags for connecting...with the revenue survey, and have laid down all the objects likely to be visible from seaward[4] [23, 118, 169].

Triangulation was continued during 1858–9—George Howard to the south and Chew to the north—and the junction was closed by Nicolson and Chew during season 1860–1[5].

TRIBUTARY MAHĀLS & KHŌND HILLS

At the end of 1858, work was resumed by both parties towards the west. No. 1, under Saxton, completed survey of the hills south of the Māhānadi, and extended triangulation southwards into Goomsur and Patna which had only been

[1] DDn. 664 (102), Saxton to SG., 31-3-58. [2] Svy. of Coast, MRIO. 59 (1-3); Report 1857–8, DDn. 336; 692 (395), 23-6-58. [3] *rasd* = provisions. [4] Report 1857–8, DDn. 336; 692 (401), Depree to DSG.; Oct. 1858, MRIO. 57 (4–9, 17–22). [5] MRIO. 59 (29); *GTS. Syn.*, xiii (42–53—C) & chart I.

CUTTACK TRIBUTARY MAHĀLS
ORISSA

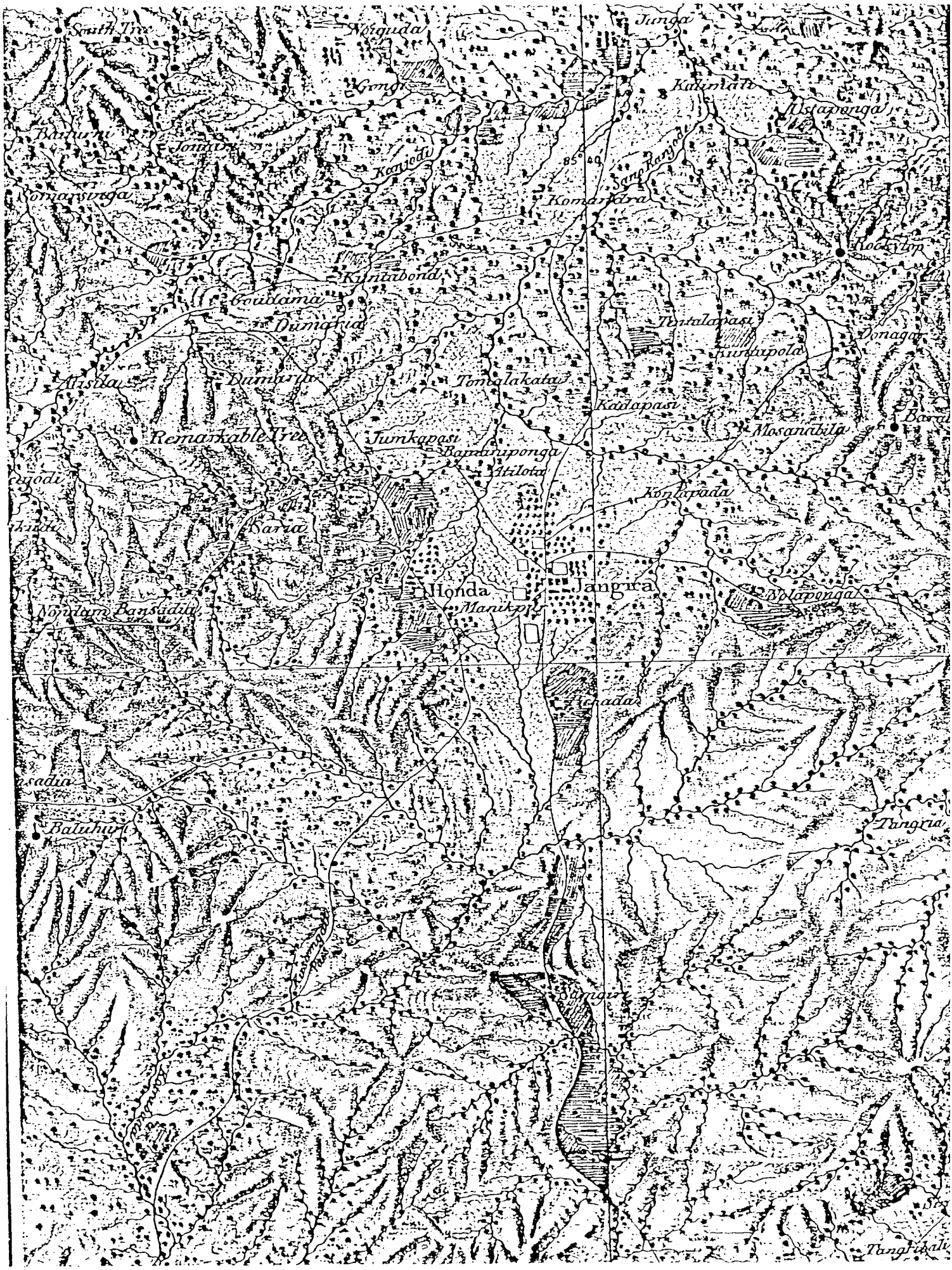
From sheet No. 4 of a series of six sheets surveyed on one-inch scale, seasons 1855–7.

Triangulation by Deprée; planetable survey by Robt. Howard and Richardson; lettering by Howard.

Fair copied in Surveyor General's Office, Calcutta, by draughtsman Sheikh Meeajan, and signed 1st July 1858.

Jangira is 16 miles south of Keonjhar [Atlas Sheets 107, 116; plate 27].

R. B. Mepell Captain
In charge No. 4 Topographical Party
Chota Nagpore Division ..... Survey.


Junga
Kalumata
Kamarkhola
Kuntabond
Goublama
Tentalapasi
Tomalakata
Kadapasi
Remarkable Tree
Jumkapasi
Bamuniponga
Jitilota
Konlapada
Karia
Honda
Jangira
Manikpur
Tangria
Baluhuri

touched by the sketchiest of route surveys [167]. Though about 3,000 square miles of triangulation and over 2,000 of planetabling wer ecompleted, the Surveyor General was shocked at Saxton withdrawing in the middle of March after a field season of only 2½ months, when he had only to observe at three more stations to make a good junction with the Coast series near Russelcondah [367 ; pls. 1, 28];

Captain Saxton advances the state of the weather from haze as the primary cause of his giving up work, the sickness of his party being only mentioned as a secondary reason.

It is well known...that the haze...gives way early in April to the change of the wind. ... If there is a bare possibility even of more work being obtained, a survey party is bound to continue in the field, and persevere in the object for which alone it is maintained. ...

The Ganjam Survey party also is now on an augmented and expensive footing [172, 422], and unless an adequate return is rendered...it will be necessary to consider whether it will not be advisable to reduce salaries and expenditure, and to revert to the old scale, or...to suspend the operations altogether if the result is so inadequate[1].

On 28th. December 1858, Depree handed over charge of No. 2 Party to Nicolson and proceeded on furlough and, whilst his sub-assistants planetabled nearly 2,500 square miles of Keonjhar and Mayūrbhanj, Nicolson himself extended triangulation northward through Mayūrbhanj ;

The Lieutenant Governor...being desirous for information regarding the capabilities of the Meghasini Hill [3,823 ft. ; pls. 1, 3] for a sanatorium, ... I marched to that station...in company with Dr. Kendall, civil surgeon of Balasore [466]. ... I...determined upon a double series of triangles along the eastern flank of the meridional series [South Parasnath] with the right flank resting on the extreme points of ridges running down to the eastward. ... By the 21st February I finished up to Rusumbani H.S. ... I then descended into the plains and traversed the whole tract lying between the hills and the revenue survey boundary of Balasore. The plains of Moharbunje...are densely wooded ; there is not a single height which could be used for a station, and very few spots here and there cleared of jungle from which the hill stations could be viewed. ...

I resumed the triangulation in the hills on the 16th March, and shortly after crossed over into Dhalboom, an independent estate under the Agency of Chota Nagpore. My progress was very slow after this as very hazy weather set in. My camp also began to be distressed from want of supplies, the country being almost in a state of famine. ... My heliotropers very frequently had to give up work and return to camp, the villagers very seldom being able to supply them with anything but mowa flower[2], upon which they themselves were subsisting.

I reached the northern boundary of Dhalbhoom on the 12th April after which I...commenced ...eastward towards the boundary of Midnapore, using hillocks for stations, and then worked... back to Moharbhunge, avoiding all very unhealthy localities as much as possible. I finally quitted the field on the 2nd May, and arrived at Cuttack...on the 15th[3].

Saxton now called attention to the unsatisfactory patch-work resulting from frequent changes of programme ;

The Surveyor General, in compliance with requisitions from different civil authorities, has from time to time directed my proceedings. The first special order required a survey of two districts in the Cuttack Tributary Mehals not lying in contact with each other, viz., Nayapur and Angul ; compliance...deflected my operations [172].

The next orders were in consequence of the Chota Nagpore Commissioner applying for a survey of three districts in that province, and I was directed by the Surveyor General to survey Sumbulpore, Odeypore, and Jushpore, which are not immediately contiguous to each other. ...

Another requisition from the Superintendent of Cuttack Tributary Mehals was made for the unsurveyed portions of his province to be completed before the Chota Nagpore country. The Surveyor General approved, ... and gave me instructions accordingly. ... I...demurred at my operations being diverted and the continuous system being upset. ... The next season my triangulation was recommended in another direction, away from the rest of my party. ...

Under these circumstances the main object, viz., continuous progress and a complete survey every season, became impossible[4].

He recommended that the two parties should separate "for encouragement of a spirit of rivalry", and that each should be given its own continuous programme.

Continuity of mapping suffered also from the want of topographical survey over the area of the revenue surveys of 1837–42, and Thuillier notes in 1870 that "in

[1] DDn. 666 (26), SG. to DSG. 12–4–59. [2] *mohwa* = *bassia latifolia*, Parker (309-10). [3] MHO. 57 (1), 58 (51-2); DDn. 594 (309) Nicolson to DSG., 8–7–59. [4] DDn. 41 (87-90), 28–7–60.

the early seasons' work the surveyors did not rendes their results in uniform-sized sheets and—the original records not being susceptible of reproduction by photo-zincography—the 1-inch maps have never been published"[1] [190 n.4].

During seasons 1859–60 and 1860–1, Saxton extended triangulation across the northern hills of Ganjam and then west into Patna and Kalāhāndi States, with a view to accelerate the publication of Atlas sheet No. 107 [310–1]. His assistants continued survey of the Khōnd Hills covering the north-west area of Goomsur and extending west into Kalāhāndi[2]. Claudius had been deputed to fill gaps in the direction of Sambalpur that had been left by Dyer's party during season 1856–7, but "the Commissioner...prohibited his entering those localities just then, and subsequently forbade his going there at all this season, in consequence of the unsettled state of the country, and those gaps remain as before". His own triangulation progressed in spite of occasional interference ;

The only irregularity in the series is owing to the Khonds near Murudi H.S. having... driven away my signallers, and at Subasing getting no signal I observed to the single tree near that station [287]. On visiting Murudi...afterwards, I had the option of fixing a station mark afresh on the ray from Subasing, or reducing the observations. The former alternative would have been at the sacrifice of a solid rock foundation for my instrument ... and I chose the latter. The direction and distance (1·6 feet) were carefully measured and recorded.

The Khonds for a long time resisted my...attempts to have the hill cleared for a station. I punished the headmen of 3 villages, and exacted a promise...that my people should be respected. The same inhospitality occurred near Lakka, and similar corrections have to be made[3]. [On another occasion] part of my camp was attacked and my people driven away, and I did not recover my tents for a week. Mr. Atkinson in another part was compelled under threats of violence to desist from surveying along one boundary [1 : 60, 289]. Many of my daks are still missing and some of my supplies from Cuttack never reached me[4].

During season 1859–60, Nicolson ran a longitudinal series westward through the Kōl country of Singbhum and south Chota Nāgpur, in extension of Depree's series of 1856–7, before handing over on Deprec's return from furlough in April 1860. He later completed the junction of the north and south sections of the coast-line triangulation, the longitudinal series from Point Palmyras being dropped [173–4][5].

During these two last seasons the planetablers of No. 2 party completed the detail survey of Mayūrbhanj State, and were then scattered to complete various gaps in the other states and to push detail survey into Chota Nāgpur. In the spring of 1861, the party[6], now renumbered No. 4, moved headquarters to Doranda cantonments near Rānchi with a view to starting work in Chota Nāgpur the following season [184]. The association of these two parties was now severed, and Saxton's party, now No. 3 Topo. Party, Ganjam & Orissa, worked steadily southward.

Naturally the survey of these wild unfriendly hills could not be carried out with any very high order of accuracy with an annual outturn of 300 or 400 square miles for each planetabler but, writes Thuillier as Surveyor General in 1863,

the country is very poor, unimportant, and sparsely populated. ... A very minute survey would, therefore, not only be impracticable or very difficult, but is unnecessary. ... The maps ...furnish correct geographical information, and give a sufficiently fair representation of the country for a first survey at a moderate cost [168].

The style of drawing adopted...has been that of the old Military Institution brought up from the Madras Presidency [II, 125–20, 314–21 ; pl. 12 ; III, 95–6 ; pl. 11]. ... The chief defects were a harsh and stiff mode of representing the hill features without due observance of relative command or difference of height. ... It is most difficult to break a long established custom, or to teach old assistants...—accustomed to a certain system from their youth up—a new method of conformity with modern improvements. ...

Major Saxton...is fully alive to the desirability of improving the finish and general getting-up of his maps. ... Supplied with good specimens of the English Ordnance Survey maps, ... I am well pleased to mark the improvement which is rapidly taking place [170–1, 291].

[1] *CR Topo. 1869-70.* Note on Index to Ganjam & Orissa Svys. [2] MRIO. 57 (14–5, 18–21) ; 58 (8–11) ; DDn. 728 (8) & 336 ; *GR. Topo., 1860-2* (27–9, 38–40) Saxton, Claudius, D. Atkinson, Harper, Adams, May, Abdul Rahman, Ghomeswar Banerjee ; *IO Cat.* (327–8). [3] DDn. 41 (37–44), Poorec, 26–5–60. [4] *GR Topo., 1860-2* [289]. [5] ib. [40–2] ; MRIO. 59 (29). [6] Deprec, Nicolson, King, Vanderputt, MacVittie, Pew, H. M. Atkinson, Babu M. S. Dal.

He is almost the only one of the party...who has not suffered severely from the ill effects of the climate. His long...knowledge of the country peculiarly fits him for conducting a survey of this nature. ... Results...[are] not equal to some of our first-class surveys of more favoured parts of the country, yet...superior to those produced by his several predecessors[1].

Saxton continued to hold charge of the party through the wild borderlands of Bastar and Vizagapatam till his retirement in 1873, Undoubtedly a higher standard of topographical survey would have been attained if communications had allowed of regular inspections and frequent transfers from one field party to another,

HYDERĀBĀD SURVEY, 1844–50

The Hyderābād party had been raised by James Garling in 1816 for the survey of the Nizām's dominions, and was administered by the Deputy Surveyor General from Madras until in 1831 it was brought under the direct orders of the Surveyor General [IV, 248]. In 1844, it was under the charge of Henry Morland who had first joined in 1828, and held charge with frequent interruptions from 1829 till his promotion to regimental major in 1848.

The one-inch survey was controlled by minor triangulation based on the Great Arc and branch triangles thrown out in Lambton's days. In 1844, the party was working in the Berār districts of Buldāna and Akola, and a complete set of 57 small sections, each 13¼ by 6⅜ inches, fair-drawn from the original field sections of the Narnāla Circār, is still in excellent condition [pl. 8][2]. The quality of survey could not, however, be compared with modern standards for, writes Du Vernet,

the quantity of detail that can be taken up monthly by an experienced surveyor is about 120 sq. miles, and though occasionally as much as 150 or 180 sq. miles may be done by him, I am of opinion that the sub-assistants...are doing well provided the work sent in be good, and that Major Morland, by demanding more work...is harassing them, and forcing them into a general mode of execution very detrimental to the Government interest[3] [290].

During field season 1843–4, with Morland on sick leave to the Nilgiri Hills and his senior assistant Andrew Chamarett holding charge, 13,500 sq. miles of circārs "Dowlatabad, Macher, Bassim, and Bythulwaddy" were surveyed[4]. In his report for 1844–5, Morland shows progress in the "Mohoor and Bassim circars", besides the completion during recess of a ¼-inch plan of "Baythulwaddy circar" and a plan of the neighbourhood of the Ajanta caves, with descriptive memoirs[5].

On Morland leaving in March 1848, the Madras Government appointed, without any reference to the Surveyor General, Major John Brown, a Madras cavalry officer without any previous experience of survey, who assumed charge on 17th July. He found that preparation of *circār* maps and memoirs was heavily in arrears, and was directed to rectify this by increasing office hours during recess rather than by reducing field work[6]. An outturn of "four square miles per diem...or 700...in the surveying season of 6 months" was still expected. Seven months later he estimated that, making no allowance "for sickness, casualties, or other contingencies," the remaining 18,000 square miles would be finished in six years; "The whole of the arrears of office work is completed"[7].

The surveyors had frequent trouble with local officials who

were most determined in exhibiting every opposition and throwing obstacles in their way, but [the surveyors] having in a very creditable manner shewn they were not to be deterred from their object, continued their work, although in many instances subjected to almost personal violence by armed men, stimulated and urged on by the village authorities, and were ultimately obliged to discontinue their work. ... The conduct of the offending parties has been brought to the notice of the Resident. The...country was generally much disturbed from the...Rohillas and other mercenaries plundering the villages, which were in many instances entirely deserted, and...no assistance or supplies were to be obtained[8] [478].

[1] *GR Topo., 1860-2* (29-35), 15–4–63. [2] MRIO. 70 (11–69). [3] DDn. 522 (266), to SG., 13–4–47. [4] DDn. 452 (329), MRIO. 70 (79–81, 115), Ajanta, Buldāna, Chikhli. [5] MRIO. 70 (3, 4, 11, 92, 121). [6] DDn. 592 (2), SG. to Brown, 21–2–49 ; svy. made first by separate *circars*, but from 1854 continuously to geogl. limits ; *IO Cat.* (283). [7] DDn. 529 (8), 29–9–49. [8] DDn. 593 (69), Report 1848–9, 14–7–49.

During 1849–50 work was carried on in Gāwīlghur and Cullum *circars*[1];

The very great heat...in the valley towards the banks of the Taptee...in the month of April greatly crippled my means...of completing this portion of the northern boundary, as the whole of my party were prostrated by fever, and at one time I had not a single available subordinate that could carry on the details beyond ten days at a time. ...

The village authorities...displayed every disposition to oppose our proceedings but, finding that we would not yield to their wishes by quitting the field, they gradually gave in, and the party resumed their duties without further inconvenience, excepting at the village of Amlah in the Koorah pergunnah, ... where we were threatened with violence. My camp was robbed and an armed party of upwards of 500 individuals assembled for...attacking our party.

The quantity of work completed this season...amounts to 1,852 square miles, and the triangulation...to the southwards and to northward was carried on by myself and Mr. Turnbull[2].

On learning of these disturbances the Resident recommended that "the survey should be discontinued or removed to another quarter, because no protection can be afforded in the present political condition of the country". The Surveyor General thought that this local opposition was largely due to Brown's lack of tact and failure to win confidence. Being, moreover, dissatisfied with his lack of professional knowledge and having no other officer to recommend in his place, he asked permission to close down the survey for at least two years,

during which interval it would be in my power to train an officer to succeed him, provided a gentleman sufficiently young and possessing the requisite elementary qualifications as a draughtsman and mathematician be selected. In the meantime the sub-assistants of the Hyderabad Survey might be dispensed with...to other efficient parties where their services would be turned to good account, and their work properly supervised. The whole party could then be re-assembled at a moment's warning whenever the Government might...order it. ... Major Brown would quit the Survey Department[3].

These proposals were approved and the survey was closed down with effect from December 1850 [384][4].

HYDERĀBĀD SURVEY, 1855–66

In July 1853, the Resident at Hyderābād agreed that the survey might well be resumed, "specially as the Berar districts, where obstacles and inconvenience formerly occurred, have lately been transferred to British management"[5].

By treaty of 1804, the Berār districts of Amraoti, Buldāna, Akola, and Yeotmal, had been ceded by Nāgpur to the Nizām [II, 133 n.1], and in 1853, on the death of the Nāgpur Rāja, Rāghoji III, they were attached to the newly formed Central Provinces for adminstration by the British[6] [III, 90 n.5]. Various adjustments as between the Nizām and the British were effected under a treaty of 1860[7].

James Mulheran, who had joined the Great Trigonometrical Survey in 1834, and had recently held charge of the topographical survey of the North-West Himālaya, was selected for the charge[8]. Leaving Dehra Dūn on 8th January 1855, he did not reach Ellichpur till 5th April, a journey of 87 days, including halts occasioned by bad weather. He commenced triangulation from stations of the Great Arc north of Ellichpur on 27th October, and with two newly appointed young sub-assistants had by April 1856, covered an area of 2,500 square miles with 675 triangles[9].

Of the establishment of 1850, Turnbull and James McGill had died, Long and James Peyton had resigned, and Leigh alone remained to rejoin from Cuttack during 1856. The younger Chamarett joined from the Punjab, and three Indian surveyors were recruited and trained [447]. With a party of seven Mulheran completed about 1,800 square miles of detail survey during season 1856–7, finding considerable discrepancy with Brown's survey of 1849–50 in Amraoti District.

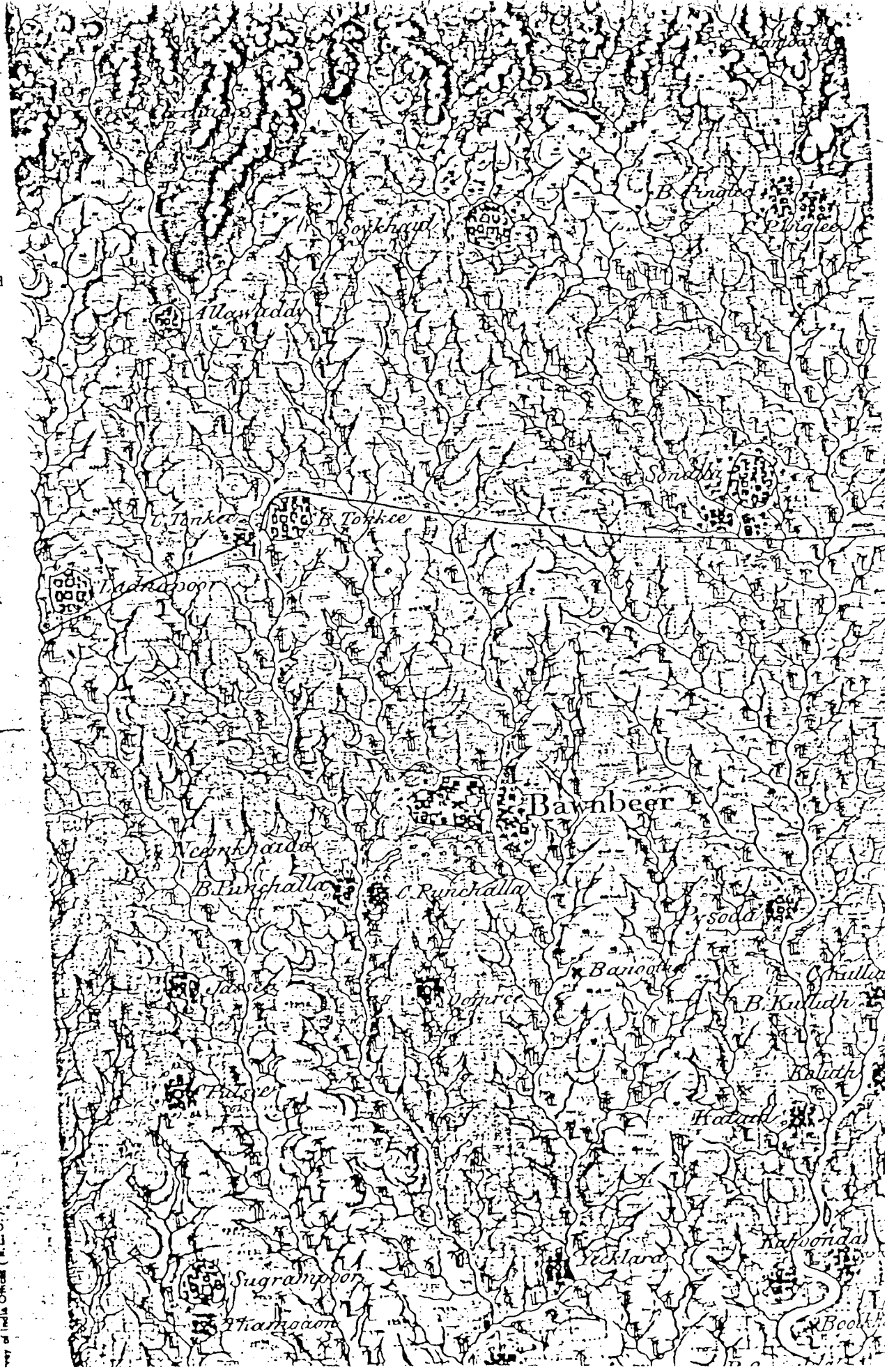
[1] maps, MRIO. 70 (95–6). [2] DDn. 593 (43), Report 1849–50, Ellichpur, 10–7–50. [3] DDn. 542 (29), DSG. to Mil. Dept., 17–7–50. [4] BMC., 8–10–50; DDn. 526 (313); 542 (271), Report, 1850–1; 1-inch *circar* maps, 1840–7, *IO Cat.* (283–4, 288–9); ¼-inch (285–7); Berār, 1844–65 (287–8, 291–2). [5] DDn. 546 (233), Readt. to SG., 5–7–53. [6] treaties of 6–6–53 & 1855. [7] MRIO. Misc. 340–O–83, 16-m. map of Nizām's Dominions & Assigned Dists. of Berār from orgl. of, 2–1–57; ib. 66 (3); *IO Cat.* (282); 24-m., shewing adjustments of 1860. [8] appd., 1–1–55. [9] Geo. McGill & James Smith; DDn. 336.

Plate 8

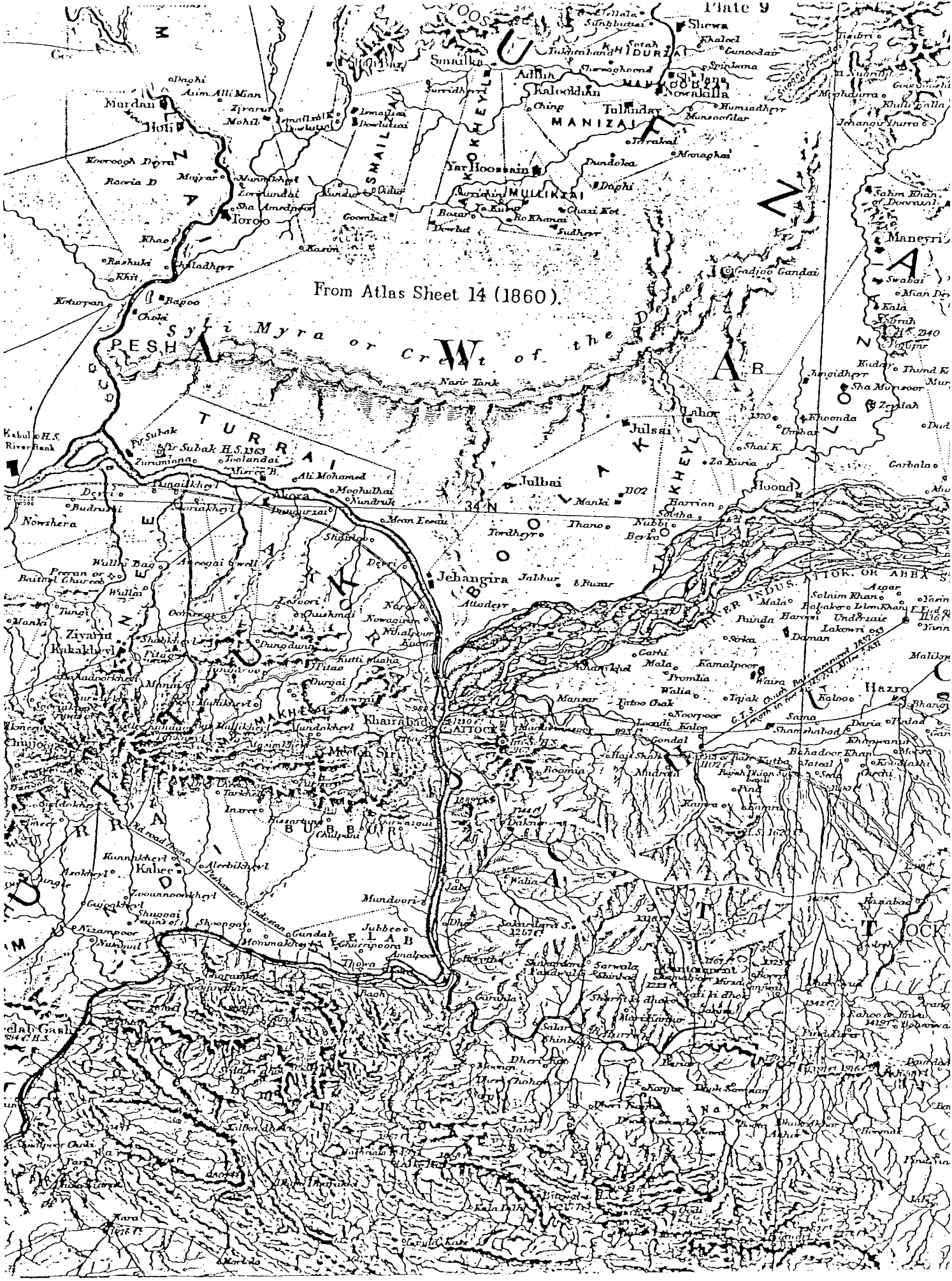
BERĀR

Narnāla Circār
40 m. W. of
Ellichpur
and below
Gawilgarh Hills

Surveyed on
one-inch scale
under
Henry Morland
1844-6



No. 6084 HD'55-80'57.
Survey of India Offices (N.L.O.)


From Atlas Sheet 14 (1860).
Sylli Myra or Crewt of the
PESHAWUR
YUSUFZAI
SWAT
BUNER
TURRAI
KOHAT
KHATTAK
BOZDAR
KHAKHEYL
MAKHEYL
KHARRAR
MARWAT
BUBBUR
DHUNDEE
MANIZAI
MULLIKHEL
SHAHMANSOOR
SHAHMANSOOR KHEYL
SHAIL
Peshawur
Murdan
Holi
Ioroo
Nowshera
Jehangira
Julbai
Julsai
Khoree
Hoond
Harrion
Attock
Khairabad
Mitun Sir
Kalee
Hazro
Maneyri
Tock
Kakakheyl
Ziyarut
Kohat
Kurram
Kabul R.
River Bank
Fr. Subak H.S. 1363
Fr. Subak H.S.
Alora
Mogulthai
Mundruk
Mean Essau
Thano
Nubbi
Borka
Tordhyr
Shinkio
Derri
Jalbur
Buzar
Attaderr
Nowagirm
Khalsoor
Kuchmai
Kuttee Kusha
Durgai
Dung dung
Kuttee
Kaimai
Kundokheyl
Manni
Muddeekheyl
Shahid
Pitag
Tungi
Ootmanzai
Zuramiana
Toolandai
Ali Mohamed
Dhoree

Although there had been a mutiny of troops at Aurangābād, and gangs of Rohillas[1] had attacked the Residency at Hyderābād, the party took the field in October 1857, with three sub-assistants and five Indian surveyors. Towards the end of the season McGill found his area overrun by troops of the rebel leader Tantia Topi, and the Surveyor General asked the Resident for an escort [485–6];

This pergana, altho' of no value per se, is...part of a tract the survey of which should be completed and free from all gaps. ... Mr. McGill acted judiciously in retiring, the Rohillas having twice advanced to threaten his party. ... It will, however, be very desirable to complete the undertaking next season, and I would strongly recommend...an additional guard.

When I carried the Great Arc series through that jungly tract in 1838–9 [IV, 42, 473], an escort of 50 horsemen was assigned to me, ... but finding the country quiet, and the inhabitants well affected, I was enabled after a short time to dispense with so large an escort[2].

In December 1858 McGill had to withdraw hurriedly from a strong party of Tantia's men, and Mulheran had to divert his triangulators to the south. He himself was running a series of triangles eastwards from the Great Arc towards Nāgpur to fix points for Vanrenen's revenue survey party [268] which

he accomplished in his usual...able style, but his progress was frequently interrupted by the disturbed state of the country and the vicinity of bands of rebels under Tantia Topi and others who were scouring across his line of operations. He himself and...his detached parties were several times in danger, but...the work was successfully carried out[3] [485–6].

For season 1860–1 Mulheran had six sub-assistants[4] and as many Indian surveyors, and completed survey of the British-administered districts north of the Penganga. Whilst McGill took a share of the triangulation, Andrew Chamarett, a first-class planetabler like his father before him [IV, 256–7 382], was responsible for training and supervision. The survey of the Nizam's Dominions with the "assigned districts" of Berar was completed by the end of season 1865–6, 20,578 square miles having been added by Mulheran since 1855.

NĪLGIRI HILLS, 1844–52

The Nilgiri Hills had been topographically surveyed on the one-inch scale by Benjamin Ward between 1821 and 1823 [III, 111–3]. In 1843 the Directors called for a large-scale survey of the cultivated areas for revenue purposes, and in March 1844, John Ouchterlony of Madras Engineers was appointed to the charge[5]. He was placed under the professional direction of the Deputy Surveyor General at Calcutta, and furnished with instruments from the Nellore topograpaical survey that had just been closed down. Charles MacMahon, also of that survey, was posted to his detachment.

The Surveyor General thought Ouchterlony should make a topographical survey on the lines of Wroughton's survey of Sohāgpur of 1841–2 [IV, 228], basing his triangles on Lambton's Great Arc that passed through Coimbatore. He supported Wroughton's instructions with an elaborate note on the conduct of trigonometrical surveys[6] [IV, 476; V, 297]. What the Directiors had actually called for, however, had been a large-scale survey for registration of grants of land;

You should be provided with a detailed survey and map of the Neilgherry Hills, distinguishing the lands in the occupation of the Government and private individuals—those brought under cultivation by the Burghers—those which are to be left in the permanent occupation of the Todas—and those entirely unoccupied, over a portion of which the Todas have been accustomed to pasture their herds[7].

On realising that the survey was to be primarily for revenue purposes, the Surveyor General qualified his earliest letters;

My despatch of the 4th October entered very fully into the details of the difficult subject of surveying a mountainous country like the Neilgherries. ... It is clear that if your survey is conducted on the accurate system proposed by me, it will not only produce all the information

[1] of Afghān orig in; for Rohilla Wars, 1774, 1794 v. Index, vol. I. [2] DDn. 656 (146), 4–5–58. [3] DDn. 594 (361), SG.'s Report, 1859–60, 6–10–60. [4] Leigh, Chamarett, McGill, Smith, Daly, Farrell. [5] MRO., 29–3–44. [6] DDn. 491 (110), from SG. 4–10–44. [7] OD. to M., 21–6–43.

necessary for the revenue statistics of the district, but will also furnish very valuable materials for geographical purposes, which may be incorporated...into the Atlas[1].

Ouchterlony was directed to combine a geographical survey for the Surveyor General with the details required for the Revenue Department. He completed this survey on scale 1,000 feet to an inch by 1848, together with a statistical memoir[2]. All work for the Revenue Department was closed down in 1851, and it was then suggested that he should employ his skilled topographical assistants to survey the Kundah Hills to the south-west[3] and also a small tract of Coimbatore to the east, completing at the same time a general ¼-inch map for the Atlas of India.

The topographical operations of the unsurveyed tracts may for the sake of expedition be taken up on a scale of 2 miles per inch in the field, but a reduction on the prescribed scale for the Atlas, will also be required, and the delineation of the geographical lines must be very carefully attended to [363][4].

Ouchterlony continued one more year under the direct orders of the Surveyor General, but the Madras Government grudged his employment on work that was of no value for revenue purposes ;

Seeing that this work has already occupied Captain Ouchterlony upward of a year, and will apparently continue to occupy him for an indefinite period in the agreeable climate of the hills, and having daily experience of the great want of Engineer officers to superintend...works of pressing and real importance and utility, ... the Governor in Council directs me to express the hope that the services of Captain Ouchterlony may be early made available[5].

His services were thereupon restored to the Madras Government[6] and the assistant surveyors discharged or transferred to other survey units. Amongst the valuable geographical material handed in were a "Map of the Neilgherries and resurveyed portion in the vicinity of Chinoor and...in the Coimbatoor District, scale 4 miles to an inch, dated 18th December 1852", besides charts of triangles [290–1][7].

In spite of the lack of interest shown by the Madras Government, their engineer at Kotagiri was anxious to get a copy of the map in 1856 ;

Captain Ouchterlony informs me that he prepared for the Geographical Survey of India a map containing in one section Danaikencottah and the slopes of the Neilgherries adjacent, together with the Hussanoor Ghaut, and in another section the valley of the Bowany River and that tract north of Coimbatore marked "unsurveyed" in the printed map.

These sections would be most valuable and useful to me[8].

[1] DDn. 491 (123–4); SG. to Ouchterlony, 28–12–44. [2] *IO Cal.* (360–2); MBIO. 129 (1), litho. reduction on ¼-inch scale ; Markham (190) ; memoir, *JMLS.* XV (1) ; connected to OTS. 1871. [3] rise to 8613 ft. [4] DDn. 542 (234) ; SG. to Ouchterlony & Mil. Dept., 26–6–51. [5] DDn. 546 (179), Ft. St. Geo. to Govt. of India, 27–11–52. [6] BMC., 14–12–52. [7] MBIO. 129 (1, a, b). [8] DDn. 677 (8), Civ. Engr., 7th. Div. to CE. Ft. St. Geo., 31–5–56.

CHAPTER XIII

TOPOGRAPHICAL SURVEYS: BENGAL, BOMBAY, BURMA

Calcutta, 1845–54 — *North-East Frontier* — *Chota Nāgpur*, 1860–1 — *Upper Provinces & Oudh* — *Himālaya Mountains*, 1846–52 — *Central India & Gwalior* — *Rājputāna* — BOMBAY — *Sind* — BURMA — *Pegu Survey*, 1853–66.

THERE is no end to the survey and re-survey of a flourishing city such as Calcutta. By 1840 the important surveys carried out by John Schalch between 1820 and 1824[1] [III, 13] had become seriously out of date, and from 1841 a meticulous survey of the outlying suburban area was put in hand under a deputy magistrate, Michael Crow [IV, 192 ; V, 249]. Surveys in Ballygunge, Howrah, and Kidderpore were carried out later by Alexander Daniell whilst head assistant at revenue survey headquarters [IV, 192 ; V, 183 n.4, 440][2].

During 1845 Frederick Simms, who had come out to India as consulting engineer for railway construction, offered to carry out a new survey of Calcutta that would meet all engineering requirements. He was asked to consult Crow and obtain his "suggestions on local peculiarities", and then to point out "the best mode in which the existing survey can be practically expedited". He was later asked to put up

a plan for making an entirely new survey of the City of Calcutta and its immediate environs, to be as minute in all details as is possible, ... and to be plotted upon a large scale whereby such minutiæ can be shown in plan for...facilitating the general improvement of the city.

He asked for four district surveyors—at least 36 detail surveyors—besides "a few draftsmen and writing clerks"—and proposed to divide Calcutta and

its environs into four districts...—the North district—the Fort district—the City district—and the South district. ... Districts would be sub-divided into small blocks...encompassed by streets or roads, each block to be allotted to one or more detail surveyors. ...

The general map should be plotted to any large and convenient scale, so that the whole might be contained upon six or eight sheets, and could be mounted to form one or more sheets. ... This...should be engraved on copper plates that it might...be preserved and altered from time to time. ... I would also recommend that the surveys of the blocks with all their detail be plotted upon a still larger scale, and bound together...for the use of the Government[3].

On Crow's death in 1847[4], Simms was directed to take over all the establishment, records, and instruments of Crow's department [249], and to organize

a proper establishment and...a plan for surveying and taking the levels of the town. ... The survey now in contemplation is...to be in aid of the operations of the Committee of Municipal Improvement which...will shortly be established [III, 13][5].

In September he put up specimens of the style of survey he proposed ;

A General Map of the City...laid down to a scale of one inch to 300 feet which, being the same as that of Punchenagrem survey [IV, 192 n.1], will readily unite with those plans to make a perfect map of Calcutta and its environs. The scale...will show every building of any consequence, and whenever a more minute knowledge of particulars is required reference can at once to made to the book of block plans upon a large scale. ... All purposes will be answered without the construction of an unwieldy and inconveniently large general map.

The size of the map of the city contained within the river, the Circular Road, and Tolly's Nullah [I : 65, n.5] will be...about 9 feet long and 4 feet broad. ... I propose...block plans... three times the scale, ... namely 1 inch to ten feet. These block plans will be numbered and referred to in a skeleton...whereby any particular block may be...referred to at once. When completed they should be bound into a volume or volumes, ... and these I would most certainly prepare in duplicate. The General Map might be engraved.

[1] *IO Cat.* (191), 132 ft. to inch. [2] MRIO. 46 (43), 186 (33). [3] BRC., 22–7–46 (47), from Simms, 8–6–46. [4] not 1846 as in Vol. IV, p. 192. [5] BRC., 18–8–47 (58).

He asked for a large increase of staff, as from the existing establishment it is hopeless to look for the completion of the survey and maps. ... The next twenty years would not see it completed. Such dilatory proceedings neither suit my inclinations nor the desires of Sir Herbert Maddock[1] with whom the City survey originated[2].

To prevent opposition from property owners, legal authority was obtained to enter private premises, though no attempt was made to survey their limits;

A notion prevails...that the business of the surveyors is connected with taxation, and that any delay...will retard the levying of taxes. ... I would suggest...making public...by beat of tom-tom the objects of my survey...and the penalties attending its obstruction. ... Refusals are not confined to the native population, but frequently occur amongst the Europeans. Especially do the durwans refuse entrance when their employers are absent. If such opposition was evinced when the object of the survey was generally believed to be the improvement of the sanitary condition of the town, how much more violent it would have become had I attempted to enquire about private property and...boundaries [I : 51–4 ; III, 12][3].

Survey was completed by the end of 1849, and three sets of the block plans were submitted on scale 100 feet to an inch, two sets bound up for local use, and the third "in four tin cases" for the Court of Directors. Simms' report of 80 pages was dated 14th August 1850, and published in Calcutta in 1851;

The boundary of Calcutta proper, or the limits of the Supreme Court, is laid down from the Proclamation of...10th Sept. 1794 [I : 54]. ... In finding the boundary at the north end of the town where much of the...Maharatta Ditch is filled up and obliterated [I : 51], I...acknowledge the assistance of Mr. J. Rowe, the Surveyor to the Commissioners for the Improvement of Calcutta, who...knows more of the local...details...than any other person living [III, 448 ; IV, 457]. ... Area of Calcutta, 7·807558 square miles. ... Population, ... 361,369 souls; probably rather under than over the actual numbers. Census carried out by Chief Magistrate gave population 413,182 souls[4].

Hirst records in 1915 that the large-scale block plans "were lent to me in connection with the finding of the High Court's...boundary. Simms' work was the first large-scale survey of Calcutta that was in any way accurate"[5].

The third set was taken home by Simms himself, and passed to John Walker, "the Company's Geographer", to be reduced as a general map for publication in London "where only it could be engraved"[6].

Simms had confined his survey to the city and municipal area of which various small gaps were filled in by surveys carried out under Thuillier's direction. The Pānchannagrām survey, however, had not been sent to England, but after completion by Smyth was made up locally with old material and published in Calcutta on the 6-inch scale in 1854 [250]. The first copies of Walker's map reached Calcutta early in 1859, bearing the caption;

Plan of Calcutta from actual survey, 1847–9, by Fredk. Walter Simms, F.R.A.S., ... Civil Engineer, Consulting Engineer to the Government of India. Suburbs of the town are from surveys subsequently furnished by Major H. L. Thuillier, ... executed by himself and Capt. R. Smyth. Revised to 1857. Reduced and Engraved by J. & C. Walker, scale 390 feet to inch, on 4 sheets, price 16 shillings, or Ten Rupees[7].

Thuillier took immediate steps to combine it with the Pānchannagrām survey;

The long-expected new Plan of the City of Calcutta engraved in England from Mr. Simms, survey...has been sent out to the extent of 25 copies only. ... This plan is a very valuable one indeed, ... shewing all the improvements up to a late date, as well as the river Hooghly and the towns of Howrah, Seebpore, &c. on the opposite bank, surveyed expressly for this purpose under my own superintendence in 1856, owing to Mr. Simms having omitted to embrace it in his survey. ... Advice has recently reached me of a large number of copies [500] having been shipped via the Cape.

From this large plan, which is on a scale of nearly 14 inches to a mile, a reduction has been made in this office to 6 inches...to connect it with Maj. Smyth's...plan of the suburbs (called Punchannogram) on the same scale, ... which I have long been anxious to lithograph to meet the pressing wants of the...new Railway Companies, as well as for the new drainage works[8].

[1] (1790–1870), BCS. Dep. Govr. Bengal, 1845–8 ; *DIB*. [2] BRC., 29–12–47 (20), from Simms, 25–9–47. [3] BRC., 24–11–47 (31), from Simms, 22–11–47 ; Report, 14–8–50, *IO Cat.* (192), fd. bks., 27 vols. [4] Simms, Calcutta, 1851 ; GBO. Lib. F-e-59 (a). [5] Hirst (*Calcutta*) (22). [6] B to OD. Rev., 7–1–52 (36). [7] Markham (407) ; *IO. Cat.* (192) ; MRIO. Misc. ; 44 (29–43) ; 45 (2–10, 14–20). [8] *GR Rev. LP., 1857–8* (29–30), from DSG., 2–4–59.

Whilst indenting for a further supply for "Government offices and sale to the public", Thuillier pointed out that there was a plan on scale 3 inches to a mile "now actually advertised for sale in Calcutta". This had been pirated from Simms' original block plans that had remained in Calcutta by Mr. Heysham, a Dy. Collector of Calcutta, and "lithographed in London on his own account "[1] [323–4]. Thuillier pointed out that the official 6-inch plan could now be obtained from the Conservancy Department, and a few months later reported that "there are plenty of Simms' plan available in this office should they be required"[2] [250].

A special copy of the new 6-inch map was mounted on rollers and presented to the Lieutenant Governor in March 1861. The map bore the legend—

City and Environs of Calcutta, including the Government estate of Punchannogram, with Allipoor, Khiderpoor, Garden Reach, Seebpoor, Howrah & Sulkea; 1852–6; scale 6 inches to one mile.

Materials—City of Calcutta, reduced from F. W. Simms' map of 1847–9—Environs... Major R. Smyth's survey of 1852— ... Pargana Majoorah, from the survey of Major Ralph Smyth of 1849–50—The Botanical Gardens from the survey of Mr. W. A. Wilson...1845–6—River Hooghly, Seebpoor, Howrah, Sulka, and Goosree, from a survey made under the superintendence of the Deputy Surveyor General in 1850[3].

Drawn on transfer paper...and lithographed by Mr. H. M. Smith, at the Surveyor General's Office, January 1863[4].

The survey of the "Hooghly River and environs of Howrah" embodied in the 6-inch map had been made by Seta Ram Missar of Gastrell's party, and in granting him a bonus of two months pay Thuiller writes that

the mutsuddee has carried out the instructions...very much to my satisfaction, and has produced a creditable survey, which was beset with many difficulties arising from the crowded state of the river with shipping, as well as from the inclement state of the weather[5].

Early in 1848, in connection with schemes for drainage and water-supply, Simms had run levels "through all the principal thoroughfares", and carried them to Palta, about 20 miles north of Calcutta. These he had based on "the zero of the tide gauge of Kyd's Dock", but he had left no benchmarks, and in 1853 Thuillier had to re-level from Kidderpore to connect to the Surveyor General's Office [70][6].

In 1852, at the request of the Governor-General a special one-inch map of the country 10 miles round Calcutta was prepared[7].

NORTH-EAST FRONTIER

Knowledge of the north-east frontier was being gradually extended, sometimes by the travels of scientists as in the search for the tea plant [IV, 204], and later by the tours of Dr. Hooker through Sikkim and the Khāsi Hills [186]. In more remote areas political officers occasionally had the company of a trained surveyor. John Butler[8] tells of a tour in December 1844 through the Nāga Hills with John Thornton [IV, 203–4, 392];

Our surveyor came into camp completely exhausted, and we thought he was attacked by fever. ... He was a very abstemious man, and was always boasting of the inexpressible delight he experienced in satisfying his thirst from every limpid stream and eating sweet biscuits. ... On this distressing march he had swallowed a quart of cold water, and he came into camp as pale as death, and talked of going to bed directly. ... We gave him a pint of warm porter, and he rallied instantly, and with a dish of hermatically sealed soup [364] and a slice of ham, he soon got over his fatigue, and ever afterwards he failed not to join our party in a substantial luncheon on cold fowl and bacon or beef with a glass of brandy-and-water[9].

The following year Butler visited the Angāmi Nāgas. He left Nowgong on 20th November with "a hundred men of the 2nd Assam Light Infantry" as escort, "an apothecary to attend the sick, as well as an uncovenanted surveyor"—again

[1] Heysham's map, 1856, 600 ft. to inch, MRIO. 44 (1). [2] DDn. 554 (28–34), from DSG., 1–6–59 & 5–3–60; also DDn. 11 (3), PWD. to SG., 16–3–60. [3] DLR. 36/25 (166), DSG. to Gastrell, 21–8–56. [4] including those by Daniell [181]. [5] MRIO. 44 (27–8); *IO Cat.* (106). [6] ib. (192), Levels of Calcutta. Simms, ms.; DDn. 563. [7] DDn. 563 (118), DSG. to SG., 12–1–53. [8] (1809–76); Ben. Inf., Hodson I (268), Pol. Dept., Assam; MRIO. Misc. 24–0–53. [9] Butler (61–2).

Thornton—who surveyed the route "and plotted off on a large scale a most valuable map of the greatest portion of the Nagah Hills attached to the district of Nowgong". They marched through "Kachoomaree, Dheemahpoor on the Dhunseeree R., thence...returning to Nowgong on 6th January 1846". A map of the route appears as frontispiece to Butler's book[1].

During seasons 1860-1 and 1861-2, John Moran, an assistant of the Sylhet revenue survey, was deputed with two Indian surveyors to accompany a military expedition into the Kuki Hills to lay down part of the boundary between Sylhet District and Tipperah State, and to select suitable sites for police posts.

Moran broke off the work without...authority, and quitted India for Europe in January 1862, without having effected any portion of the survey, and "I have never heard of him since. ... He simply left a letter behind him to inform me [S.G.] that private affairs of the most pressing and painful nature compelled him reluctantly to take the step[2]".

CHOTA NĀGPUR, 1860-1

It was not until 1861 that a systematic topographical survey was started of the wooded hills and uplands of Chota Nāgpur, though in early days adventurous officers of the Rāmgarh Battalion, and others, had sent in rough sketch maps and route surveys [I : 35 ; II, 44-7 ; III, 27 ; IV, 268-9], and Joseph Olliver had carried the Calcutta Longitudinal series across the northern hills [III, 262].

After discussing the division of responsibilities between the revenue survey party under George Thompson [244], and the topographical party under Depree, it was decided that Depree's party should extend triangulation from Orissa into south Chota Nāgpur during season 1860-1, and move headquarters from Cuttack to Rānchi at the end of that field season. The Deputy Surveyor General recommended that Depree's party should cover the entire division with triangles, and

delineate such portions...as the local civil authorities may point out as requiring a topographical survey only, while such pergunnahs or estates as require a revenue detail survey should...be made over to the Revenue Surveyor. The difficulty in the present state of our information of this wild and hitherto unknown country is to ascertain precisely what does require the detail survey of the larger scale. ... I am very desirous of any arrangement that may...expedite the general survey of the Division, estimated at 37,000 square miles[3].

Depree moved his party up to Rānchi in the spring of 1861, and the limits of work between the two parties were left for local decision [176, 244].

UPPER PROVINCES & OUDH

A certain amount of topographical survey was carried out by the parties of the Great Trigonometrical Survey and included the running of ray traces or lines of minor triangulation to fix main rivers, or towns, villages, and other important objects [118-9]. A useful map was compiled from route surveys run by Du Vernet's assistants when selecting stations of the Karara series, and covered the country between Rāe Bareli and Lucknow [103, 119][4].

When Hill moved the Karara party to the East Coast in 1845 [23] the Surveyor General directed him to survey his route ;

As...your party will be wholly unoccupied by public business on their march, ... it will be advisable to employ them in prosecuting a route survey along the high road from Allahabad. This route should be computed and plotted every day. The mean of two perambulators should be used for the distance along the road. ... Intersected details should be either defined marks taken from two stations, or measured up to by perambulator, and laid down by direction and distance. The route should be carefully joined on to those stations of the Great Trigonometrical Survey which happen to lie in the vicinity of the line of march[5] [23, 169, 288].

[1] Butler (61-75) ; MRIO. 37 (9), Thornton's svy. with sketches of scenery. [2] *GR Rev., 1858-61* (166-170). [3] DDn. 668 (331), DSG. to S.G., 28-6-60 ; *IO Cat.* (282-3), Topo Svy. 1858-63. [4] MRIO. 33 (37) ; 4 m. to inch ; cf. route svy. by Hennessey & John James, *IO Cat.* (227). [5] DDn. 600 (194), 1-9-45.

In 1848, the Collector of Gorakhpur asked for a survey of the great Gogra River which "should be established as a thoroughfare for commerce, to open up access to the districts of Oude...with a steamer service between Calcutta and Fyzabad [pl. 1]; great would be the glory and benefit to Oude by thus coaxing the main stream of Indian traffic from the Ganges to the Gogra".

At the request of the Resident at Lucknow, Clarke Gaskoin of the Artillery carried out this survey between March and May 1853, working with prismatic compass and chain, and sounding with a pole. He worked down from Fyzābād to Chapra and then returned up stream noting the changes. "Hardly a single boat proceeds beyond the boundaries of the Company's provinces owing to the heavy and arbitrary taxes levied by the zemindars holding forts and the headmen of the villages in the Kingdom of Oude"[1].

Gaskoin found no place with "less than four feet of water in the driest season", and reported that the river "could easily be made navigable for steamers up to Byram Ghat, 30 miles above Fyzabad [II, 29–31]". His maps were reduced to the scale of 8 miles to an inch at the Surveyor General's office and 600 copies were printed at Black's press for issue with his official report[2].

As this survey had no trigonometrical control, it was useless for mapping purposes, and later in the year Nicholas Belletty of the *Hurilaong* series was deputed to make a trigonometrical survey up the river from its junction with the Ganges to its debouchment from the mountains, some 350 miles. Belletty carried out this survey by minor triangulation starting from the Hurilaong and connecting with the Gora, Gurwāni, and Karara series. The minor details were sketched by eye, as the river banks were not well defined, and it "does not follow the same course for two successive seasons"[3] [13]. His survey showed considerable disagreement with the revenue surveys of 1835–8, which preceded the principal triangulation [IV, 223–6].

Between 1845 and 1847, Ommanney [IV, 459–60 ; V, 244] and Wyatt [252] were demarcating a portion of the Nepāl boundary with Bihār east of the Gandak, and during season 1859–60 revision was made of the boundary with Oudh.

Government have determined to restore to the Nepaul State the former Goorkha possessions below the hills, extending from the river Gogra on the west to the British territory of Gorackpore on the east. The territory...to be ceded is that portion obtained from the Nepaulese in 1815 and which in 1816 was made over by the British Government to the Nawab of Oudh [III, 19–20]. ... You will furnish this Department with any information that your office can supply as to the old boundary between Nepaul and Oudh[4].

The early maps included surveys by Thomas Wood, 1802–3 [II, 26–7], and Peter Grant, 1818 [III, 20–22]. The new survey was carried out by Frederick Anderson, Revenue Surveyor, who was appointed one of the Boundary Commissioners. His survey stretches between meridians 80° and 82°, and shows boundary pillars and line of theodolite traverse, besides the triangles of the North-East Longitudinal series which run parallel with, and close to, the boundary [263–4, pl. 4][5].

Surveys were made of the Grand Trunk Road by Public Works officers between 1848 and 1850[6], and of a number of cantonments and cities by revenue surveyors[7] [252, 324]. Other maps include Keelan's survey of the Surveyor General's march from Dehra Dūn to Peshāwar, 1849–50 [36, 202, 337], and surveys of Delhi taken by William Dodsworth during the siege of 1857 [IV, 397][8].

HIMĀLAYA MOUNTAINS

Throughout his term of office Waugh shewed the utmost interest in the geography of the Himālaya mountains, and in 1847 he took the opportunity of the

[1] *FD Sel.*, IV ; Gaskoin to Resdt., 17–8–52 ; his map on 1½ inch scale was 27 ft. long. [2] DDn. 563 (277–323), 3–4–to 26–6–54. [3] DDn. 591 (203), from SG., 23–7–52 ; Report from Belletty, 23–7–60 ; DDn. 4 (171). [4] DDn. 650 (5), FD. to SG., 17–9–59. [5] *IO Cat.* (470) ; MRIO. Misc., 64/5–O–60. [6] MRIO. 30 (11–17) ; 12 (37). [7] Jhānsi, Lucknow, Meerut, Moorshidābād ; MRIO. 185 (20–1) ; Misc., 18–O–54 ; 29–31 7–O–59 ; MRIO., 12 (40–1). [8] MRIO. 183 (25), Misc., 46–O–57 ; GBO Lib. map E 4.

measurement of the Sonakhoda base-line to visit Sikkim himself and fix the lofty snow peaks of that region. Such a survey had been suggested by Reginald Walker in February 1847, after selecting the site for the base-line [19-20] ;

With reference to the orders of the Court of Directors...on the importance of laying down as many secondary points as possible, and especially all important places within 30 minutes of the principal triangulation, I have the honour to draw your attention to the desirability of having two points in the Darjeeling and Sikkim Hills at a considerable distance apart, from which...the...high mountains of Kanchin-Janga...might be laid down with great accuracy, and also the various points in those territories[1].

After Walker's unfortunate death Waugh carried out this triangulation himself [83], and the Superintendent of Darjeeling, Doctor Campbell, suggested later that the points fixed might well facilitate a survey of the whole Darjeeling tract[2]. Commenced by Henry Maxwell of Artillery in 1849, this survey was taken over the following year by a detachment under Robert Smart from Sherwill's revenue survey party and completed during 1851 and 1852[3] [255].

The intention was [writes Hirst] to make a survey on the general lines of a revenue survey, and certain areas were surveyed on the 4-inch scale ; these maps are now [1920] of little use. The hilly tracts were surveyed on the 1-inch scale over Darjeeling and Kurseong subdivisions. Survey based on G.T. stations ; detail not very accurate ; differences of level by form-lines. A few small town areas were surveyed on scales 6...and 20 inches to a mile[4].

A six-inch map of Smart's survey was lithographed at Calcutta and gives the names and areas of "locations at Darjiling in tabular form". The map runs as a half-mile strip northwards from the plains extending in two branches from Darjeeling northwards to "Rungeet" and Birch Hill. It shows Jālapahar and Lebong[5].

A one-inch map of the "Hill Territory of Darjiling" shows two Morung *parganas* in the plains to the south and extends 8 miles north and west of Darjeeling to include the Singalilah Range which forms the boundary with Nepāl. The map is bounded on the east by the Tista River, and on the southwest by the Mochi. It gives a table of rectangular coordinates of triple-junctions of *parganas*, and gives area of Darjeeling District as 740·17 square miles ;

The local beegah in use equals 1600 square yards. Boundary defines lands ceded by the Sikkim Raja to the British, 1st. Feb. 1835. ... Notes on Hill Tribes from Dr. A. Campbell. ... Notes on graphite south of Kursion. ... Notes on vegetation from Dr. J. D. Hooker[6].

Dr. Hooker, the celebrated botanist, was travelling in Sikkim between 1849 and 1850, and was held up for several weeks by the State authorities [183]. With Thomson he has left a sketch map shewing his routes, and the general position of Kangchenjùnga and other mountains as fixed by Waugh[7] [83]. There is also an 8-mile Map of Sikkim

illustrative of Dr. A. Campbell's trip...by J. A. Crommelin, late Major of Bengal Engineers [III, 435], Darjeeling 26th May 1849. The principal peaks round Darjiling were trigonometrically determined by Lt.-Col. Waugh...in 1847–48. Heights by him are also shewn. Details taken from a rough map by Dr. J. D. Hooker and from observations of Dr. Campbell[8], [also a] sketch of the Rummon River, copied in Surveyor General's Office 1850, from the little Rangit River to Singalila Range on the Nepal frontier ; scale 2 m. to inch. Explored by Dr. T. Thomson and Lieut. H. H. Maxwell, Artillery[9].

In August and September 1846, after the conclusion of the Amritsar treaty [220 n.5] Alexander Cunningham was employed as Joint Commissioner with Patrick Vans Agnew[10] to delimit the north-east boundary between the British and Māharāja Gulāb Singh of Jammu towards Ladākh and Chamba. Survey work fell entirely on Cunningham [IV, 269] , whose map covered Rupshu, Lāhul, and Spiti. The mission left Simla on 6th August and, travelling by Bilāspur and Sultānpur, crossed the Bāra Lācha La on 5th September, the anniversary of its passage by Moorcroft and Trebeck in 1820 [III, 43]. They visited Morari Tso [234–5 ; pl. 6] and returned by

[1] DDn. 513 (69), Walker to SG., 8-2-47. [2] DDn. 472 (529–31), 26–5–48. [3] DLR. 37/57 (70); sketches by Sherwill; 37/47 (186, 188); DDn. 533 (72), Sherwill to DSG., 14–12–50. [4] Hirst. [5] MRIO. Misc., 14-0-51. [6] *IO Cat.* (199); MRIO. 38 (1) 4-inch reduction, by John Murray 1-11-53 ; *IO Cat.* (199). [7] MRIO. Misc., 17-0-50, ¼-inch scale ; cf. *JRGS.* XX, 1851 (IV, 40); MRIO. 55-0-61, litho. copy ; *JASB.*, XIX. [8] MRIO. 90 (33). [9] MRIO. 173 (41); Thos. Thomson (1817–78); Burkill (78). [10] (1822–48), BCS., kd., Multān, 20–4–48.

the Rohtang Pass on 5th October. A description of the boundary and the country covered, with a reduction of the map, was published by the Asiatic Society of Bengal[1].

At the same time sketches of the southern borders of Jammu were made by James Abbott, now Deputy Commissioner of Hazāra [IV, 416–7 ; V, 208][2].

In 1847, Cunningham was deputed as British Commissioner for the north-eastern frontiers of Gulāb Singh's territories having as assistants Dr. Thomson the botanist [186 n.9], and Henry Strachey of the 66th N.I. ; Vans Agnew had charge on the north-west towards Gilgit with Ralph Young of Engineers[3] as surveyor. Cunningham travelled to Kashmir through Hazāra, up the Jehlum valley to Srinagar, and then up the Sind to Ladākh.

After exploring the sources of the Indus to the north-east the party assembled at Leh on 2nd October and, writes Cunningham on 9th,

we purpose to leave Le tomorrow morning. ... Dr. Thomson will proceed to Nubra and up the Shyok to its source, and if possible he will cross the Karakoram Range for a few marches, ... after which he will return by the Shyok River and follow its course down to Iskardoh. I have furnished him with a sextant and a surveying compass of my own. ... He has also minimum and boiling point thermometers. ...

I will myself take a southerly route by following the Indus...to the Dras River, which I will survey to its source. From Dras...I will proceed...to Astor, and...across the Indus to Gilgit. Lieut. Strachey...will...take the river route. We shall thus have three distinct routes surveyed from Le towards Gilgit. ...

To the general accuracy of Trebeck's survey [III, 43–5 ; IV, 269] I can speak personally, as on three different occasions, in 1839 [IV, 269], in 1846, and during the present year, I have myself surveyed many portions of his route. I have likewise...surveyed many portions of Vigne's route, and...state positively that his surveys are in many places erroneous [IV, 472][4].

Cunningham compiled his map in Simla during 1848 and notes that

the sketch map...by Dr. Thomson supplies in a satisfactory manner the long desired survey of the Shayok, or Nubra, River. ... With Lieut. Ralph Young's survey of the middle Indus in the Iskardo and Gilgit territories, and Lieut. Strachey's and my own surveys of the Upper Indus in Ladak, the Government will now possess a complete survey of the Indus and its tributaries from Hanle to Gilgit [147 ; pl. 6][5].

This Map of the Alpine Punjab [IV, 209], scale 8 miles to an inch, was passed to the Surveyor General's Office in December 1851, and gave the first clear view of the sources of the Upper Indus and the lofty regions of eastern Ladākh[6]. Strachey's report gave a descriptive memoir, with geological notes by Thomson who was the first Englishman to reach the Karakoram Pass. The Surveyor General had at no time been consulted about these surveys.

In 1846 Strachey had visited the twin lakes Rakas Tal and Mānasarowar, and returned with sketches of northern Garhwāl and Kumaun. These he compiled into a general map based geographically on the published sheets of the Indian Atlas with many heights inserted from boiling-point observations.

In the trans-Himalayan part of my map I have copied...Indian Atlas No. 65, which shows the explorations of Moorcroft and Hearsey in 1812, ... unaltered up to longitude 81° [II, 80–1]. East of that longitude...is the result of my own explorations, ... including the lakes with the... details of Kailas and Gangri, the eastern and south-eastward sources of the Sutlej. ...

My survey was a very rough one made with pocket-compass (Schmalcalder) and a watch ; ... even these rough methods...were often interrupted by night marches.

In my map I have...explained the distinction between agricultural villages and mere temples and monasteries—places permanently inhabited and mere encamping-grounds—and all other requisite discriminations, the neglect of which...together with the abominable kakography of names, has much impaired the value of the sheets...of the Indian Atlas [III, 297 ; IV, 304][7].

In May 1847, his brother Richard also visited Kumaun, but devoted himself largely to physical geography and a survey of the glaciers of the Nanda Devi group.

[1] ¼-inch map, MRIO. Misc. 11–0–46 ; *Ladak* (3) ; *JASB.* XVII, 1848 (201–30, 295–7). [2] DDn., 469 (3–4), RD. to SG., 10–10–48. [3] (1825–97); *Conolly* (90/233); Young's svy. map, 9 m. to inch, MS., *IO Cat.* (256). [4] from Cunningham, 15–9–& 9–10–47 ; *JASB.*, XVII, 1848 (89–92); cf. *Ladak* (7). [5] from Cunningham, 7–1–48 ; *JASB.*, XVII, 1848 (101) ; cf. *GTS. Syn.*, VII (XXV—C) ; Mason (80–1) ; *IO Cat.* (232). [6] MRIO. 7 (30–1) ; *IO Cat.* (232) ; *JASB.*, XVII 1848 (106–32, 295–7) ; Strachey's maps, *IO Cat.* (223, 256) ; MRIO. 25 (16) ; 88 (10, 14–5) ; ib. M 590 ; NY *Atlas* (11, 12) ; Burrard & Hayden (239). [7] *JASB.* XVII, 1848 (527–37) with map p. 120 ; Mason (80–2).

In 1848, his services were placed at the disposal of the Government of the N.W.P. for "scientific researches in Kumaun and its vicinity". He also visited Mānasarowar and later wrote a long essay on the general level of the snow-line[1].

A map of Kumaun and British Garhwāl by John Batten [IV, 419; V, 86, 318][2] when Settlement Officer gives a delightful profile of the snow range.

In the *Himalayan Journal* of 1929, Sir Geoffrey Corbett discusses the name "Himālaya". He points out that *Hi-ma* means Snow, and *a-la-ya* means Abode. Hence *Himalaya*, Abode of Snow [1: 77]. The every-day Englishman pronounces all four vowels short, though Indians accent the first "a" long.

CENTRAL INDIA & GWALIOR

For administrative purposes the term "Central India" covered a number of self-governing states of Bundelkhand and Mālwa lying between the North-Western Provinces on the north and Central Provinces on the south, Chhatarpur to the east and Indore to the west [pl. 1]. It did not include the state of Gwalior. Except for Franklin's survey of Bundelkhand between 1813 and 1819 [II, 51–2 ; III, 81–2] there had been no surveys of this large area other than those based on route surveys and astronomical latitudes, the best of which had been those by Gerard during 1824–5 [III, 89–90].

Since those days the area had been traversed by the triangles of Everest's Great Arc and of the Calcutta Longitudinal series from Sironj. Topographical maps were sorely needed for administrative purposes. In 1849, the Resident at Indore asked for a survey that "should have nothing to do with boundaries of states, districts, pergunnahs, or villages"; if it were clearly notified to all chiefs that it would not interfere with such questions, it would then have their support[3].

In 1851, the Resident at Bhopāl, Henry Durand [IV, 431–2], asked whether the Surveyor General could not supply a later map than Sir John Malcolm's of Mālwa & Adjacent Countries [III, 84, 275], that had in 1845 been adjusted to the triangles of the Great Arc and re-issued on the 8-mile scale [315][4]. Triangulation had now advanced westward [pl. 3] and Waugh thought it would be

> very easy to take up the topographical delineation in a complete systematic manner...to show the configuration of the ground, the position of every village, and extent of forest and cultivation. An undertaking of this extent would not cost more than 4 or 5 rupees per square mile, and I would gladly recommend such a work...if I had sufficient instruments[5].

Neither staff nor instruments were available, and though Durand employed a surveyor named Butterworth [IV, 386] to survey "the Rajgarh and Narsingghar chieftainships", no triangulation points could be furnished.

The Resident at Gwalior was anxious to get surveys started in that state ;

> Scindia's Government, which is under a very intelligent young chief, and a still more intelligent dewan, ... are anxious to have a good map of their countries, divided into pargannas, etc., and...have taken people into their service competent for such a job. It would be a great assistance, however, ... if the triangles laid down by the Grand Trigonometrical Survey could be furnished. ... This survey is for the use of the Maharajah, and could...never compete with any work...conducted by your scientific officers. Still it will be useful and, emanating from the Maharajah himself, shews that the people begin to...see the necessity of having their country surveyed, instead of groping in the dark as they formerly did[6].

In 1854, Sir Robert Hamilton, Resident at Indore[7], made a firm request for the settlement and survey of the boundaries between the various Mālwa states, each contributing a monthly sum towards the expense. He pointed out that

> in the settlement and mapping of boundaries a vast deal of...topographical and statistical information can be collected, ... highly useful to the native states as well as to our Government, whilst the hitherto constant source of angry feeling and bloodshed will be removed[8].

[1] DDn. 461 (369-70); NWP. to SG., 14-2-48; map, MRIO. 15 (16); *JASB.* XIX, 1849; XVI, 1847 (794–812). [2] MRIO. 25 (15). [3] DDn. 617 (75), to Govt. of India, 17-5-49. [4] *IO Cal.* (264). [5] DDn. 557 (89-92), SG. to DSG., 7-2-51. [6] DDn. 560, to SG., 25-7-52. [7] (1802–87), Bart.; BCS., AGG. CI., 1854–9; *DNB.*; *DIB.* [8] DDn. 641 (174), AGG. CI. to FD., 23-1-54; FD. sanction, 28-2-54.

The following year the Governor-General in Council expressed

a favourable opinion regarding...an uniform continuous survey of natives states within the... Agency of Central India. ... The states to be surveyed will be Rewah, Adjaigurh, Chirkari, ... Duttiah, and Chhatterpoor. ... Gwalior territory will also have to be brought under this survey, as well as the Bhopal Agency. ... Other independent chieftainships bordering Malwa...must be included, as well as the states...in the valley of the Nerbudda bordering Guzarat. ...

The value of a...topographical map of such a vast...tract of country needs no comment. ... The cost in the first instance must be borne by our government, as it will be very difficult to equitably distribute it amongst the states and chiefs. All have readily consented to the survey[1].

The Surveyor General estimated the area as about 77,000 square miles, that would require three field survey parties of 8 surveyors each ;

A well-trained topographical surveyor can execute on an average five square miles per diem, ... about 700 square miles per season. A complement of 8 surveyors ought therefore to execute, say, 5,600 square miles per annum...at which rate the survey of the whole 77,000 square miles of Central India states would take only 5 years to complete [289–90]. ...

As I have not at this moment any spare officers or establishment, it would be impossible to start 3 parties at once. They must be organized gradually and successively, and this...will extend the probable time of completion to 8 years at least. ... The total cost...will be, say, 7 lacs, 74,634 rupees. This...is the lowest sum which a survey of this extent...will cost if a respectable standard of accuracy be aimed at, but it may cost a great deal more if it is not efficiently organized [and] ably conducted[2].

Hamilton forwarded this estimate to Government, pointing out that several states had offered to make small contributions towards the cost. A start had been made by Captain Evans "who has a small but efficiently organized party". Government thought that a general survey might be made by employing Burgess's revenue survey party in laying down and surveying the state boundaries [267], whilst Evans worked under the professional direction of the Surveyor General[3]. When it was however found that Evans had only two Indian surveyors to assist him, and that his survey was confined to village boundaries in Dewās State, the Foreign Department directed that

immediate measures may be taken for the settlement of all boundary disputes, and the demarcation of all boundaries, not only between native states and British districts in Bundelkhand, but between all the native states in the Province, in order that every preparation may be made for the topographical survey of the whole[4].

No steps could, however, be taken towards such survey owing to the lack of staff and the outbreak of the mutiny, which led to prolonged military operations in Central India. Late in 1859, the Government of India raised the matter again ;

Many of the military arrangements were frustrated altogether, or much impeded, owing to the entire ignorance of the practicable roads, passes, ... and ghats of rivers, in Malwa, Rajpootana, Saugor, and the Hussainabad territories. ... The Commander-in-Chief having strongly urged the necessity for an immediate military survey of such rivers and hilly countries, ... you will inform Government as to the knowledge possessed of the districts west of the Ganges, especially in or near to Bundelcund, Central India, Nagpore, etc.[5].

Thuillier forwarded this to the Surveyor General, reporting that,

anticipating these wants during the campaign, I published...several maps...on the uniform scale of 8 miles to the inch. These...embrace very nearly the entire limits specified, ... and comprise all the geographical information forthcoming in this office [315–6]. ... As respects the larger question of a proper survey of this immense area, I await your instructions[6].

Waugh called attention to his *Report to Parliament* [345–6] which showed that

the greatest portion of the area...has never been under regular survey, and that the geographical information...depends on routes executed by the Quarter Master General's Department and other scanty...materials. ... The necessity for a regular survey...I have long felt ; ... the undertaking has, however, ... been postponed for want of sufficient survey parties. ... Great progress has now been made in the Punjab and Bengal. ...

Captain Robinson's survey party has just completed the military survey of Hazara, Rawalpindee and Jhelum in a style of unsurpassable excellence. The establishment is now actively

[1] DDn. 661 (31), AGG. CI., Jhānsi, to DSG., 30-3-55 ; copy to SG., 4–6–55. [2] DDn. 547 (363), SG. to AGG., 30–6–55. [3] DDn. 641 (148), FD. to AGG., 14–9–55 ; H. L. Evans, Mālwa Bhīl Corps, 1842–61 Comnr. Bdy. Disputes, 1855. [4] ib. (195), FD. to SG., 31–10–55. [5] DDn. 649 (160), Mil. Dept., to DSG., 30–8–59 ; of SG.'s, 6–10–60 ; *GR Topo. 1860–2* (7). [6] DDn. 668 (167), DSG. to SG., 5–9–59.

engaged in completing the fair maps and records which may...be out of hand by September 1860, and by October...I hope to...transfer this party to the Gwalior territories[1] [214].

Authority was obtained for the transfer of Robinson's party, and the consent of the Gwalior durbar was readily granted though no state contribution could be made[2]. Work was to be based on the G.T.S.;

The Great Arc...runs through the centre of the Gwalior territory and will form the basis of...operations. Unfortunately many of the stations...which were fixed five and twenty years ago were wantonly destroyed a few years after [IV, 86]. ... This misfortune will no doubt entail some delay...and expense, but I believe that a sufficient number of undisturbed stations exist to enable the secondary triangulation...to be established satisfactorily[3].

Survey was to extend continuously over Gwalior and all contiguous states, which are much interlaced with one another, while detached portions of some states are isolated by other territories. Considering that the...present survey is to produce a complete and final map of the whole country on an adequate scale, rather than a survey of any particular state or district, I propose to instruct Captan Robinson to carry the work forward from the Chambal in a continuous sheet, whereby the whole country will be completely mapped. ...

Tonk, Jhalawar, Bhopal, Rajgurh, parts of Holkar's territory, Dhar, etc., will fall within the scope of this general survey as it proceeds south to the Nurbuda. ... In this way complete blocks of maps will be produced of the entire country without gaps or omissions. ... In no other way can we expect to obtain satisfactory results...nor...can the atlas sheets of the Great Indian Survey be rendered complete and final[4].

An advanced detachment left Dehra Dūn in October 1860 under charge of William Murray, and started triangulation in the neighbourhood of Dholpur;

Triangulation will be carried down to a little over the 26th degree of north latitude... The observations should be final so that it may never be necessary to revisit a station. ... The eastern portion will be made under Lieut. Murray assisted by Messrs. Bell, Neale, and native surveyor Kalka Pershad, the western under Mr. Hörst, assisted by...Abdool Sammad Khan.

The western portion and all south of a line drawn through Thankri...due west and east... can be triangulated in the ordinary way with a network of triangulation, but about Goormi and Bhind the country is quite flat, well wooded, and cut up by extensive ravines.

Mr. Bell is now carrying a minor triangulation down the Banganga to connect with another minor triangulation conducted by Mr. Neale, which also connects with various great stations. When the Chambal ceases to be the boundary of the Gwalior and British States, this minor triangulation should be continued along the boundary, and up to the river Sind until the ground becomes fit for your usual network. ... The one object to be held in view is to furnish plenty data for the planetable surveyors next season[5].

Field work continued till early April by which time observations had been completed from 176 stations, and an area of 4,140 square miles had been covered with points for nearly 20 planetable sections—each of 15′ square—on the 1-inch scale. This area covered the states of Dholpur and Karauli of Rājputāna, with the portion of Gwalior north of the capital and bordering on the British districts of Agra and Etāwah. Much of the flatter ground was "densely wooded and intersected by...small streams, whose banks, like those of the larger rivers, are fringed by belts of intricate ravines...ill adapted to the usual operations of a topographical survey". In some areas magnetic iron ore prevented the use of the compass[6].

RĀJPUTĀNA

The only regular survey that had been carried out in the Rājputāna states had been that of Bharatpur by Alexander Boileau between 1829 and 1832 [III, 26–7; IV, 271–2]. Much geographical knowledge had, however, been collected by officers of the Quartermaster General's and the Political departments, particularly during the Shekhāwati expedition, both by route and boundary surveys [IV, 272–3]. Amongst such surveys was that of 1853 of the boundary between the states of Mārwār,

[1] DDn. 666 (88), SG. to DSG., 23–9–59. [2] DDn. 713 (216), Mil. Dept. to SG., 23–9–59. [3] DDn. 687 (34), 17–4–60. [4] DDn. 713 (259), SG. to AGG., 10–8–60; contrast the patchwork progress in Orissa [175–6]. [5] DDn. 714 (221), Party Order, 23–1–61. [6] *GR. Topo. 1860–2* (7–9); SG., 15–4–63; maps, *IO Cal.* (267).

Pālanpur, etc., by John Brooke on the 1-inch scale[1]. There are also boundary surveys —Bhawalpur-Bikaner, 1844, —Bahāwalpur-Khairpur-Jaisalmer, 1849-50 by John Becher, and C.F. Jackson—a route survey, Bahāwalpur-Sirsa, by Edward Robinson[2] —and occasional surveys by Robert Baigree, a most pleasing artist[3].

Sir John Low, Agent to the Governor-General in Rājputāna between 1848 and 1852[4], gives the official policy towards the surveying of Indian states;

We are occasionally obliged to survey parts of the boundaries of districts belonging to Native States preparatory to settling violent disputes respecting the occupation or cultivation of portions of land. This is part of our duty which always gives rise to some bitterness...on the part of those who lose the land in dispute. ...

The prejudice on the part of the Rajpoot Rulers is so strong against all surveys that it would, I think, be a bad policy on our part to insist upon having even the borders of their territories surveyed, except when disputes...actually arise. In those cases...our right to make use of surveyors and their instruments is no longer disputed.

There was a striking proof in Rajpootana about two years ago of the strong prejudice... against all surveys. British officers were...surveying the Ajmere District [265–6]. They did not leave our own land, yet, when they approached near to the border of the Oodepoor State, the chiefs and zumeendars of that state repeatedly threw various obstructions in the way of our survey operations, and were at last so unruly and violent...that Lieut.-Colonel Dixon was obliged to send a detachment of Company's troops to protect the surveyors[5]. ...

I think, therefore, that we had better adhere to the system which has been sufficiently successful, ... viz., to avoid having recourse to scientific surveys of any lands belonging to our native allies, excepting when they become necessary to enable us to settle disputes which shall actually have arisen. The plan...does not apply to the Trigonometrical Survey, which only establishes the exact positions of certain small points that are generally at great distances from each other. That survey also avoids meddling with villages, or tanks, or rivers, or fields[6].

BOMBAY

Survey of the Bombay Deccan and of the Konkan had been carried out in the days of Sutherland and Jopp before the office of Deputy Surveyor General was abolished in 1833, and the Deccan had been covered with ¼-inch maps in the form of degree sheets [III, 124–7; IV, 240–1, 306]. None of this work was, however, accepted for the Atlas of India because the triangulation could not be trusted. The greater part of Gujarāt had not been surveyed since the days of Monier Williams, and the sad state of the maps was described by the Resident at Baroda in 1849;

I need hardly tell you how many references there are from the political officers of Rajkote, the Mahee and Rewa Kanta's, and Pahlunpoor, as well as the Collectors and Magistrates, ... regarding robberies and boundary disputes in...which the absence of a good map is felt. ...

Of the map of Guzerat and Kathewar there is but one sheet in this office, being the western and least valuable one. ... The map was compiled in 1807 by Colonel Reynolds [II, 283–4]. ... There is another map in a very delapidated condition compiled in 1820 by Colonel Williams [III, 280–1], ... but in such a simple matter as tracing the line of march from Tunkuria Bunder towards Malwa I found it sadly defective[7].

The Chief Engineer[8], who had since 1833 become responsible for maps and surveys, had no materials from which to prepare better maps; "Much valuable geographical information...had for years past remained...exposed to destruction by time and vermin". He recommended that it should be connected "by minor triangulation with the Great Trigonometrical Survey"[9], and the Surveyor General welcomed his suggestion that a small topographical party should be formed under an engineer officer to work under the control and direction of Harry Rivers;

The principle of carrying on the proposed (internal filling-up) survey in complete subordination to, and in aid of, the Grand Trigonometrical Survey appears to me sound. ... To

[1] DDn. 546 (291), to AGG. Rājputāna, 6–11–53; MRIO. Misc., 31–0–53. [2] ib. 12–0–48; 12–0–49; 17–0–47; 14–0–50; *IO Cat.* (258, 260–1). [3] MRIO. 82 (7), 12 (7); 84 (29, 42), Misc., 57–9, 63, 66–0–60. [4] (1788–1880); Mad. Inf.; KCB.; GCSI. [5] Chas. Geo. Dixon (1795–1857); Bon. Art; comdg. Merwara L. Batt., 1836, till death. [6] DDn. 713 (440), AGG. to FD., 31–7–49. [7] DDn. 544 (402), to Bo. Govt., 22–1– & 14–2–1849. [8] Geo. Jervis [II, 409], CE. Bombay, 1843–51. [9] DDn. 541 (216–8), Bo. Govt. to Supreme Govt., 25–2–50.

this end it will be indispensable that the new party should join Lieut. Rivers and, acting under his general directions, should follow up his operations...filling in his triangles with topographical details as soon as he completes them[1].

In April 1850, a young engineer officer, Castle Boddam, who had recently arrived in India, and had no previous survey experience, was given charge of a party of ten Indian pupils from the Bombay Engineering Institution [III, 384 ; IV, 383], and directed to get into touch with Rivers, who was at Abu preparing to start a meridional series southwards into Gujarāt[2] [57]. Without waiting for G.T.S. data Boddam took up work in the Idar Hills north of Ahmadābād in November ;

Finding that the sites for the different stations of the Great Trigonometrical Survey had not been selected, and that some time must elapse before they could be made use of as bases, ... I employed the young surveyors...on ray-traces for about two months and a half.

By the end of January sufficient points had been fixed for planetabling and I was enabled to commence the topographical survey. I had then only two months of February and March and a small part of April remaining for field work. The sand-storms which prevail, and the clouds of dust raised by cattle in the neighbourhood of villages, ... quite precluded the possibility of observing angles[3].

Though they had two experienced survey instructors during the first season, the young pupils took little interest, and the outturn of survey was meagre and of very poor quality. Neither of the instructors took the field during the second season, 1851-2, and the work produced during the two seasons was of little or no value[4]. In January 1852, the Surveyor General was asked to take over charge of the survey, but he considered it impossible to continue without trained officers and assistants, and he had none available. On his recommendation, therefore, Boddam's party was broken up during February 1853 [449-50][5].

Amongst scattered surveys carried out in other parts of the presidency was one of Rājpipla State and parts of Baroda lying between the Narbada and Tapti rivers. This was carried out by John Pollexfen, of the Quartermaster General's staff between 1852 and 1855, with the assistance of draughtsmen and "guides". The map on ¼-inch scale was "accompanied by statistical returns shewing every village, with its number of houses and probable number of inhabitants"[6].

There is an undated map of "part of the Island of Salsette" by James Colquhoun of the Bengal Artillery, scale 400 feet to an inch[7] with wonderful hill-shading.

SIND

The province of Sind came under regular British administration as part of the Bombay Presidency after the battle of Miāni, 17th February 1843. William Baker, the distinguished canal engineer from Bengal [IV, 417] had been given charge of surveys, canals, and forests, and directed to put in hand "a rapid and efficient detail survey, to be connected hereafter by the Great Trigonometrical Survey"[8]. A start towards this end was made by the measurement of a base-line by Robert Maclagan[9], and a small area of triangulation. A few assistants were obtained from Bengal with experience on revenue surveys, and employed on surveys connected with land revenue or canals[10]. Early in 1845 Baker was relieved by Walter Scott, of the Bombay Engineers, who hastened to consult the Surveyor General, and was advised to start some sort of triangulation [276] ;

The desert waste will...be sufficiently laid down by routes. ... Boundaries can be defined by a circuit route, checked at intervals by trigonometrical points. The great river Indus deserves to be laid down by a minor triangulation along its banks[11].

Scott replied that as he had "not been able to attend personally to the survey this season, I have allowed the assistant surveyors to continue the system they

[1] DDn. 543 (52), SG. to CE., 17-5-50. [2] DDn. 519 (113, 116); CE. to Boddam, 30-5-50 & 4-1-51. [3] DDn. 544 (644, 657), Boddam to CE., 17-10 & 12-12-51. [4] 4 sheets, *Regr. of Maps, Bombay*. [5] DDn. 542 (332), SG. to Mil. Dept., 20-9-52 ; CD. to B. (Mil.), 20-10-52 ; BMC., 23-12-52. [6] *Bo Sel.*, XXIII ; *IO Cal.* (456), also Muhan, 1849, ib. (247). [7] MRJO. 106 (7). [8] Sd. H. M. Durand, PS., 22-8-43. [9] Conolly (89/202); base-line interrupted by Liari R. [10] incl. Wm. Chill [IV, 391]. [11] DDn. 491 (150-69), 3-3-45.

were accustomed to in the revenue survey of the North-Western Provinces. Next season they shall work by triangles"[1]. Waugh thought the staff of 11 surveyors besides the Superintendent to be quite inadequate.

The duties on which the establishment...is employed...consist not merely of operations for geographical and revenue purposes, ... but include also the conservation of forests, the superintendence of irrigation, repair of watercourses, construction of canals, duties...of a mixed character which in no country in Europe...have hitherto been united together. ...

It is clear that canal surveys must be speedily undertaken for the double purpose of regulating the supply of water on economical principles, and developing the immense resources of the country by fresh works. These canal surveys, if well executed, will of themselves furnish a considerable quantity of geographical material. ...

My connection with the Scinde survey commenced in November last, in consequence of the Hon'ble Court of Directors orders that the Surveyor...should be placed in communication with the Surveyor General of India[1]. ... It will not be in my power to supply any assistants from the survey establishment under my personal control. ... This...and the want of first-class instruments has...precluded me from...detaching an efficient party of the G.T. Survey to Scinde[2].

By 1849 little had been accomplished of any value;

Major Baker, the first Superintendent of Canals and Forests, and Major Scott who succeeded him, had had considerable difficulties to contend against, and...the survey of the country—an object of primary importance—has only been partially executed. ...

Major Scott's account of the basis upon which alone the success of all canal operations must depend, namely a correct survey of the whole country, is very imperfect. He would seem to have been rather feeling than seeing his way, and it is evident that these important works cannot proceed satisfactorily until a series of triangulation is carried through the country, and its topographical features delineated on a large scale[3].

After Scott's departure in 1849 the officiating Superintendent[4] reported that the amalgamation of the Scinde Survey with the Department of Canals & Forests appears... to have almost nullified the former. The officers were withdrawn from their legitimate duties to attend to pressing business on the canals, and the assistant surveyors were employed in making detached surveys and levels of these. ... The Department has not been conducted upon any regular system. Small portions of triangulation, detached boundary surveys, and forests, etc., have been made...to serve some immediate object, and now the results of this work lie in the office in a very promiscuous shape[5].

A young Engineer officer, Alfred De Lisle, was now appointed to charge of the surveys, but the post was abolished in April 1850 [8, 276–7][6].

At this time the Quartermaster General at Bombay sent the Surveyor General a copy of a ¼-inch "map of Scinde" compiled in his office, which he feared is not entirely free from errors, and some parts...are not correctly put together, though it is the best that could be compiled at the time. An entirely new map of Scinde is now under construction...on the scale of 8 miles to an inch, on which more dependence may be placed[7].

In 1852 when Strange was bringing his Great Longitudinal series to its close at Karāchi the Surveyor General noted that "Sind is nearly a terra incognita". The following year the Commissioner in Sind, Bartle Frere [470 n.2], asked for a survey of the boundary with Baluchistān, and John Rossenrode who had just resigned from the Bombay triangulation party, was to report to the Assistant Collector who was laying down the boundary from the Hab River northwards[8]. Rossenrode was due to reached Karāchi in September 1853 but never arrived[9] [413]. Frere continued to press for regular survey of the province and wrote to the Surveyor General from Upper Sind;

I am at present in districts...of great extent, and yielding from three to four lacs of rupees of revenue, a great part of which has been in our possession for 12 years. But the only map sufficiently complete and accurate even to regulate my marches by is a rough sketch...drawn up from memory by the Deputy Collector in charge. ... The...maps are nearly blank, with the exception of a...single line measured...along the high road from Roree to the Bhawulpoor boundary. ...

[1] DDn. 454 (315–7), 26–3–45. [2] DDn. 453 (272–5), SG. to Sec. Mil. Bd., Ft. Wm., 24–6–45. [3] Bo. RC. 51/1849 (3–4), from CE. to Bo. G. in C., 22, 6–49. [4] Capt. James Henry Graham-Crawford (1812–60), Bo. Engrs. [5] DDn. 465 (770) to Comnr. Sind, 28–9–49. [6] *IO Cat.* (447), ¼-inch map of Lower Sind, dated April, 1850. [7] DDn. 544 (29), 9–2–50; QMG.'s route map Bo. Presdcy., 1846, incl. Sind; *IO Ca'.* (416, 448). [8] DDn. 545 (531), Strange to Comnr., 23–9–53 (547). [9] DDn. 651 (67), SG. to Govt. of India (pol), 4–10–56.

I have abstained...from pressing Government to undertake works which could be executed in but an imperfect and inferior style, trusting that, as the Great Trigonometrical Survey proceeded, means would be devised to execute a topographical survey of that character for which no data but such as the G.T.S. furnishes can form a suitable foundation[1].

Waugh hoped that he could leave Strange with the 2nd Hill series to undertake a survey of Sind after the measurement of the Karāchi base-line, but this did not prove possible. He was not hopeful of the rough survey that Jacob had started in Upper Sind [IV, 448][2] because,

without a thorough professional training and a well-grounded theoretical knowledge, very few men do succeed in producing good surveys. ... The Sind Frontier survey...being intended for revenue settlement purposes as well as topography, ... Colonel Jacob's opinion as the chief revenue officer must have great weight. ... For local purposes, military and fiscal, the plan may be useful, but for geographical purposes the materials are of no value[3].

On Jacob's posting to the Persia expedition his survey was carried on by George Macaulay till he went on furlough in July 1856[4]. In that year one of the Punjab revenue survey parties was sent down to Sind under John Macdonald to remain there for several years on both revenue and topographical surveys [277–9].

During 1857–8 a survey of Karāchi harbour was carried out under William Parkes the harbour engineer [74][5] who also reported on Madras harbour, 1876.

BURMA

Before 1824 knowledge of the geography of Burma had been confined to its coastline and to the course of the Irrawaddy River between Rangoon and Ava, as surveyed by Thomas Wood during 1795 [I : 84]. There was little opportunity for survey during the campaign of 1824–6, but the provinces of Arakan and Tenasserim were then ceded to the British, and gradually opened up to survey [III, 67–80][6], whilst various enterprising officers found occasion to cross the formidable mountains between Assam and upper Burma [IV, 264–5].

Early in 1852 relations between Burmese and British were again broken off, and British troops landed in Martaban and Rangoon under the command of an old surveyor, now Sir John Cheape [III, 432–3]. The campaign involved troublesome operations against dacoits and other "difficulties with which the unfortunate General, without map, and compelled to trust himself to guides, had to contend"[7]. It was closed under the proclamation of 30th June 1853, by which the British annexed the province of Pegu covering the whole of Lower Burma[8].

In March 1852, a map of Lower Burma on the 16-mile scale was compiled and printed at the Surveyor General's office, and was, writes Thuillier, a fair proof

of the advantage to be derived from the combined efforts of the Drawing and Lithographical Branches...under one superintendence [327–8]. The whole business of compilation, transferring, and printing, was got through in a very short space of time, and the impressions have been coloured and...forwarded to the authorities at Rangoon by the first steamer. ...

The style of the map is indifferent on account of the extreme haste with which it was done, and because the press in which it was printed is a very inefficient one[9].

This map included a small sketch of Martaban—later part of Thaton—" constructed by Mr. A. Hobday under the superintendence of Captain Henry Hopkinson" [244 n.2]. Later maps of Martaban were produced from surveys by Hobday and Samuel Hellard of the Indian Navy between 1853 and 1856[10].

During 1852 several officers, including Depree of Artillery and Yule of Engineers, were employed on construction of roads and reconnaissance of the passes over the Arakan Yoma, and Yule compiled and described a valuable map[11] [III, 517];

[1] DDn. 644 (200), Comnr. to SG., 9–2–55. [2] *Bo Sel.*, XVIII (102, 121–5), from Pol. Supt., 18–2–58. [3] DDn. 651 (67), SG. to G of I. (PWD.), 4/11–10–56. [4] HMS. 548 (47, 133); Admin. Upper Sind Frontier. 11–4–57. [5] *IO Cat.* (451), 750 ft to inch. [6] Maling, Asst. Survr. of teak forests, Tenasserim, 1844–5; relieved by Salmond, 1846; BRP. 23–10–44 to 28–1–46. [7] *AHQ. Burma* (103–6). [8] *Imp. Gaz., Burma*, I (23). [9] DDn. 470 (265–6), 12–3 & 24–4–52; *IO Cat.* (304) [10] DDn. 690 (152–4); 5 to 18–6–56, appreciation of Hobday's srvs. with order for 500 copies, *IO Cat.* (310); MRIO. 157 (60); *JRGS.* XXVII (58). [11] MRIO. 157 (8); *IO Cat.* (305); 3 m. to inch; Calcutta, July 1853; *RGS. Progs.* 1, 1855 (269, 440).

The hill country from the Pyng road to the Mau river is from my route surveys, ... laid down by compass and watch, the rate of pacing being frequently...corrected by bearings to prominent mountains. The central part...along the Togoo River is laid down only from distant observations with some details from information. ... The Toungoop Pass from Toungoop to Thaledein and the Alegyo Pass from Toombo to Sandoway are also from my route surveys. In the former I have also made some use of a survey by Lieut. Forlong of the Madras service[1]. The coastline is from the charts of Capts. Lloyd and Ross [III, 17, 499]. The Irawadee principally from...Wood's survey [I : 84]. ... I have also used a survey by Capt. Trant [III, 507-8]. ...

The most northerly route from Hein Tsakan to Pyng...from a journal kept by Capt. F. MacGrath in 1837 [IV, 265]. The continuation of the Aeng route...to the Irrawadee is...from ...Trant and Pemberton [III, 66, 71, 494]. The Talakh road...to Kooloong mountain is by someone attached to Genl. Morrison's army in 1825 [III, 68-70]. I have also used a sketch made for me...by a very intelligent Mugh soldier. ... The branch road from Thade joining the Toungoop Pass is from a rough fieldbook kept by Lieut. Ripley, ... Arrakan[2].

The route from Padoung on the Irawadee northwards to the Medde River is from a survey by Lieut. Forlong...in March 1853. The branch road from Padoung joining the Toungoop Pass is from a route survey by Capt. Alves, 18th M.N.I., during the first war [II, 376].

It has been no easy matter to combine these materials: ...: The difficulty has principally arisen from...an error in the relative longitudes assigned in existing maps to the Arracan coast and the...Irawadee, by which the intermediate space is unduly reserved. ... The Alegyo Pass —my distance by road is 90 miles—in a straight line 60—distance by Calcutta map 35·2. ... The difference is...preposterous. ... From Maphe Myo at the eastern base of the mountains to Memboo on the Irawadee, a pretty straight and level road, Capt. Pemberton's route table gives 3 marches, ... 38 miles. Yet the *same* Captain Pemberton at the *same* time published an elaborate map of the whole eastern frontier, and *there* we find this same distance...laid down as 10 miles instead of 30, because the assigned longitude couldn't afford more, and so it remains on the latest published maps.

He produces other evidence to show that the Irrawaddy should be shifted further east and the Arakan coast west, an adjustment he carries out in his own map[3].

PEGU SURVEY, 1853-65

After the occupation of Pegu the Government of India authorized a survey to be carried out under the direction of the Chief Commissioner, with a view to obtaining a general quarter-inch map of the whole province, the area of which was "roughly estimated at about 33,000 square miles[4]".

Charge was entrusted to Edward Williams of Bengal Engineers, who had no previous survey experience. He commenced towards the end of December 1853 by the measurement, with William Trevor, of a line between Rangoon and Pegu, and then with Richard Oakes took a line south-west towards Henzada. Work during this first season "was of a desultory character...consisting of mere routes and sketches of detached portions". He consulted the Surveyor General ;

I have commenced by running a network of traverses with theodolite and chain... to determine...as many landmarks...as possible, with the intention of filling in with the compass hereafter, a map on the scale of 4 miles to an inch, possessing moderate pretensions to accuracy, being required as quickly as possible. ... A triangulation would undoubtedly have been more satisfactory, but it involved...a previous examination of the country. ... I have it, however, in intention to commence after the rains—and carry on simultaneously with the present survey—a triangulation, by which the work...may be checked and corrected[5].

Waugh replied with a long discourse on the advantages of rigorous triangulation, and sent a copy of his professional instructions on topographical surveys [211, 282]. The difficulties, however, of triangulating a flat wooded country such as lower Burma were obvious, and Williams decided to rely solely on his theodolite traverses. "In order that one uniform system should be followed...new officers worked with the Superintendent for a few weeks before going out on their own".

[1] Maps by Forlong, MRIO. 91 (28-9); 156 (54, 59). [2] John Peter Ripley (1801-57), Ben. Inf.; Hodson, III (660). [3] DDn. 624 (112), DSG. to SG., 5-4-56. [4] *P.D. Sel.*, XX. [5] DDn. 644 (59), 25-4-54.

Robert Stewart of H.M. 84th Foot and Ferdinand Fitzroy of Artillery joined in time for season 1854–5, whilst Oakes and Trevor took charge of the area between the Arakan Yomas and the Irrawaddy. The department was expanded by local recruitment—"a dozen boys were obtained from the mission school at Kemmendine" —but out of twenty recruited by February 1855 only eight proved of any value.

There was not, writes Thuillier, a single surveyor of any previous experience, and this in a country the most difficult, perhaps, ... within the limits of the Indian Empire, for deadly is its climate, dense are its jungles, and flat is its surface. ...

In the first place the basis of the map is formed by a series of traverse lines from 30 to 50 miles apart, coincident with the parallels of latitude, intersected by a meridional series of similar form. Besides computation these traverses are plotted on the one-inch scale, and then reduced to ½-inch scale for compilation. ...

One native surveyor was allotted for detail survey of each village circle, submitting the field-book of one circle before proceeding to the next. The surveyor plots his work on ½-inch scale and it is then enlarged by pentagraph to the one-inch scale and adjusted to control points, and the one-inch *teik* or circle map fully completed with all its detail. This one-inch map is again reduced by pentagraph to the ½-inch map for incorporation in the general map.

There was no general adjustment of the main traverse frame-work[1].

At the end of April 1855 the first compilation of about 7,000 square miles of survey was submitted to Calcutta with request for 250 lithographed copies for the Commissioner of Pegu[2], but Thuillier sent the map back ;

The size...is very large for the extent of the information given in it, much blank paper being visible. A reduction to half scale therefore seems very advisable, which cannot easily be done in this office. ... The routes through the Aeng Pass, and the position of Kyouk Phyoo, and other details laid down by Capt. Yule, should...be duly incorporated prior to the labour and expense of lithographing it. ... Lieutenant Williams informs me that by...December next he will have all the work of the past field season ready. ... It would be preferable to wait for this before multiplying an incomplete map. ... To pass such a map through the press would take at least six months[3].

At the end of April an 8-mile map, signed by Williams on December 1855, was submitted in two sheets. It was compiled from

route surveys by Allan, Garden, Hobday, Yule, Harris, Pollok[4]—charts by Winser, Ward, Fell, Lloyd, Ross, Halsted, Johnson, Duncan, Horton, Twisden, Darcy—sketches by Sparks, Fytche, Brown, McClelland [142][5], O'Reilly, Dangerfield [III, 436], Shuay Line. ...

The departmental survey of Williams, Trevor, and Oakes during season of 1854 and 1855, and of Stewart and Fitzroy during 1855, which include the Prome district west of the electric telegraph line from below the frontier which is by Allan and Garden. The Henzadah District west of the Hleing River as far south as Aing-tha-Biew, the connecting line thence to Bassein and...the Arracan coast. ...

The Suay Dagon Pagoda, Rangoon, is placed in 16° 47′ north latitude, and 96° 13′ east longitude[6].

This map was lithographed at the S.G.O. in December 1855 and, writes Thuillier, is the only map of the Pegu Division prepared or published up to this date. Looking to the time and the means at his disposal, this map was a remarkable production, reflecting the highest credit on Lieutenant Williams, and it is to be deeply regretted...that this officer could not have concluded the operations in Pegu[7].

There were now many changes among the staff ;

Mr. E. Johnson of the Bengal Marine was posted to the survey from November 1855, for survey of the creeks of the Delta, but he was removed in April 1856, without having accomplished anything. ... Mr. J. R. Swetenham joined in November 1856, to succeed Mr. Johnson as River Surveyor. With the assistance of the Superintendent he initiated his survey of the rivers and creeks by the measurement of a base-line.

In July 1856, Captain Stewart resigned, and at the close of the recess Lieutenants Trevor and Oakes...were succeeded by...Edgecome and MacMahon. The latter officer, ... was...trans-

[1] DDn. 690 (1–20), SG. to Mil. Dept., 2–9–64. [2] MRIO. 155 (22–3), 4 m. & 8 m. to inch. [3] DDn. 554 (8), DSG. to SG., 5–7–55. [4] *IO Cal.* (307), proposed road Prome to Rangoon, Scott & Pollok. [5] John McClelland, Supt. Teak Forests ; Geol. sketch of Upper Pegu, Rangoon, 10–11–55. [6] MRIO. 155 (20–1) ; *IO Cal.* (306) ; longitude determined by Trevor by chronometer from Calcutta, Jan. 1856 ; values by Grant in 1825, 16° 47′ 55″ N., by 96° 13′ 27″ E. [III, 184] ; true values 16° 47′ 48″ by 96° 9′ 8″. [7] DDn. 690 (1). SG. to Mil. Dept., 2–9–64 (para 9–20).

ferred to the civil department as an Assistant Commissioner [*inf*] and was succeeded by Lieutenant Blair, whose services were also lost to the survey for some months.

On 17th September 1856, Lieutenant Williams...was succeeded by...Lieutenant W. H. Edgecome, ... and on the 12th December Lieutenant Pearson, Bengal Artillery, was nominated to fill a vacancy. ... On the 9th December...the military assistants were reduced to three. ... On 20th August 1857, Lieutenant Blair...reverted to regimental duty, and did not rejoin till the field season of 1858–9. ... In December of the same year...Lieutenant Pearson was removed...at his own request, but this vacancy was soon filled by Captain Scott.

The progress...(1857–8) is reported to have been much retarded, more especially in the Delta, by dacoits, sickness, and the difficulty of procuring labourers to clear jungle, but the progress...is recorded at nearly 5,000 square miles...in addition to about 800 miles of river survey. ... Before the conclusion of the last field season [1858–9] Captain Scott...was compelled by ill health to leave the department, and...Lieutenant Blair had rejoined. ... The area remaining for survey was at this time inconsiderable. ... There remains now nothing to be done but the completion of the Delta and the survey of the eastern boundary of the Toungoo District, ... except, perhaps, here and there, a stream to be continued to its source.

When Fitzroy took over charge from Edgecome in December 1859, the survey had been in progress six years, and it was estimated that 9/10ths of the field-work had been completed, but towards the end of 1860 a Government committee—formed to report on the arrears of mapping—agreed that all the maps should be recompiled. Fitzroy spent the next two years therefore, in re-assembling the detail work, and in resurvey on the ground, accepting only the earlier traverse framework. In his report for 1859 he claimed that all the earlier maps had been constructed "on the faulty principle of working from the part to the whole" and, writes Thuillier, that the calculations of the main traverses are incomplete and the survey of some main lines not begun. He set to work to arrange the mass of routes and sketches made by the native surveyors into some intelligible shape. ... [He] started by plotting the earlier traverse lines on the projected six sheets of his map with the aid of nine or ten native surveyors, and in season 1860–1, sent his surveyors out to survey the gaps that were disclosed on the two sheets completed.

In 1862 this compilation was rejected, and a fresh start made with the general map projected in four sheets. ... In December 1863, one sheet out of the four...was submitted to the Surveyor General's office for lithography, together with a map of Rangoon and Environs on scale one-inch to a mile.

In a later appraisal of Fitzroy's work it is stated that,

in contrasting the work...with that of his predecessors, it is very evident that his is much the most valuable, as he took the necessary steps to execute a more detailed survey than their's and to furnish one-inch *teik* maps in addition to the ½-inch map[1].

Thuillier however, blamed Fitzroy for not making straightforward reports to the Chief Commissioner for whom he was working.

During 1862 the Commissioner refused a suggestion that Fitzroy should be given control of the revenue survey then under McMahon's charge ;

If the topographical survey had already completed maps...shewing all the detail which a revenue survey requires, I should give Capt. McMahon copies of these maps and discharge his surveyors, but this is not the case. ... Any delay or mistakes in the topographical survey (and experience has proved that both are not unlikely...) would seriously impede...Capt. McMahon's work. The importance of the revenue settlement is so great...that...we should not be justified in adopting any measure which contains...the possible elements of hindrance. ...

Allowing that both Captains Fitzroy and McMahon would work together most cordially, ... we know what casual accidental misunderstandings...will arise between two distinct departments, and...it will be far better to...allow Capt. McMahon to continue work under his own immediate superintendence[2].

McMahon did not think much of the topographical survey ;

Several important creeks and streams are left out in a map...lent me by Capt. Fitzroy, and acknowledged by him to be approximately correct. ... One of my surveyors is sufficiently suggestive ; "It is all very well to fix the positions of the principal villages by the sun and moon and the stars, but what use is it when a river as large as the Rangoon River is not included ?"

The topographical survey has been going on for some 8 or 9 years, and about a third only ...completed. The remaining 2/3rds have to be done over again. The cost of this amounts

[1] *OR Topo., 1864–5* (15); *teik* = admin. circle of village areas. [2] DDn. 690 (135–58) to Ch. Comnr., 5–9–62.

to about Rs. 25 a square mile. The revenue survey under the Settlement Commissioner nearly accomplished as much at a cost of under Rs. 4 per square mile in 4 years[1].

As might be expected, Fitzroy had a great deal to say in reply.

During season 1862-3 Fitzroy had three European assistants, Montgomerie, Cooper, and Barnett, with nine Indian or Karen surveyors. He was joined in March 1863, by Arthur Bagge of Bengal Engineers, and took him out for triangulation across the Arakan Yomas. The triangles covered a distance of about 30 miles with sides of from two to six miles, and average triangular error 11", maximum 25". The height of peak Sab-ba-pon Taung, latitude 18° 30', was found to be 4,003 feet by mercury barometer and 4,261 by aneroid [69].

The hills...were everywhere covered with bamboo and tree jungle. They are totally uninhabited, and the deadliness of their atmosphere is proverbial. ...

Stations were formed by cutting off the head of a well-grown tree, leaving the trimmed trunk 20 or 30 feet high. A bamboo platform was then constructed in such a way that it in no place touched the tree trunk, on the top of which the theodolite was placed.

For signal an inverted cone of bamboo matting filled with stones was suspended from bamboo slats and centred over the mark, and red and white flags were also fixed. ...

By this triangulation is obtained an initial point for the Arracan survey, whose relative position in reference to Rangoon is thus accurately determined[2] [195].

In September 1862, Fitzroy sent in his first ¼-inch sheet ;

The execution is not what it ought to be, but the fact of it's having been accomplished during an almost incessant rain will form...a sufficient excuse.

In the survey and construction I have had many difficulties to contend with. ... I have been compelled to graft my own on to the broken work of others. I have laboured throughout single-handed, and deprived of the confidence of the local Government.

I have, however, always born in mind the advice given at the end of the 1st chapter of your book [*Manual of Surveying*] and have *willed* my way onward. To that book...I am almost entirely indebted for all the knowledge of surveying that I have. ... The 2nd sheet, which will be much superior to the No. 1, I hope to have finished in about a month.

There were so many corrections to be made that the map was referred back for action to Fitzroy who was now on a visit to Calcutta, and the map was then accepted for lithography[3].

It was not until August 1863, that the survey was placed under the full control of the Surveyor General, and in January 1864 Thuillier received Fitzroy's first report which he found most confusing. In September 1864 he sent Government a full history of the survey. From 1853 an area of about 25,000 square miles had been surveyed on the ¼-inch scale at an average cost rate of nearly 16 rupees ;

Had the operations been under proper professional control, the Government would, for such an outlay, have derived a good practical survey, even on the one-inch scale, with all the maps...brought up. ... The ground...work, is faulty in the extreme. The Superintendent... trusts to his work closing on paper, and on such a small scale the most serious errors are not perceivable. ... The fault lies entirely with the Government for authorizing...operations of this nature being conducted for years by inexperienced officers, without any professional... instruction. ... Zeal, energy, money, and more valuable time, have...been expended without any commensurate return.

During the years 1853 to 1859...much was done in the field which was not systematically or finally mapped at the time. ... Had the survey been under the control of this Department, a second season's work would never have been allowed to proceed until the former one was both mapped and computed, or else rejected and done over again. ...

The survey...has no pretensions to scientific accuracy owing to the very basis...being liable to large errors. It is...made up of mere routes and sketches, without any actual check, and liable to any amount of accumulated error. ... The Superintendent is, however, not responsible for this. He...has had a very difficult country to deal with, and he had no means of learning, devising, or executing any better system. ...

The survey as it stands must...be made to answer all present purposes, and, until the great triangulation of the Eastern Frontier [5, 33]...extends down to Rangoon and Cape Negrais we shall not have the means of testing the value of any of the positions[4].

[1] DDn. 690 [146] from McMahon, 1-9-62 ; reply by Fitzroy, 18-9-62. [2] DDn. 690 (1-20), SG. to Mil. Dept., 2-9-64. [3] DDn. 30 (1227), from Fitzroy to SG., 26-9-62, and office note, 21 (261), SG. to Mil. Dept., 11-12-62. [4] GTS. reached Prome, 1870 ; Rangoon, 1875.

Thuillier blamed Fitzroy for having concealed the lamentable state of the work ;

> His reports...are absolutely unreliable. It should have been his first and honest duty to discriminate between what was good, and what was bad. ... It is preposterous that the Superintendent of a survey should, after being five years in uncontrolled charge, continue to condemn the materials left by his predecessors, and still make use of them as it suits his purpose.
>
> The local Government and the Government of India have systematically been misled both as to the proper progress made, and as to the average cost of the work. ... The rates...are altogether chimerical, and only half the province has been finally mapped[1].

On the Surveyor General's recommendation Fitzroy was removed from charge and Edgecome brought back to Rangoon to bring the survey to a speedy conclusion. In August 1865, Edgecome returned to Madras, where he completed the mapping with the assistance of Barnett and Cooper. Montgomerie was left to complete the last of the field work, and joined at Madras five months later.

The last of the four $\frac{1}{4}$-inch sheets was lithographed at Calcutta in 1868[2], whilst 64 township maps followed on the one-inch scale[3].

[1] DDn. 690 (1), SG. to Mil. Dept., 2–9–64. [2] *IO Cat.* (306); MRIO. Misc. RS., 1609–D–09–SL. [3] *GR. Trig. & Topo., 1864–5* (14–6); *Topo. 1865–6* (41); appx. I (v–vi), 14–6 ; SG. Fd Corr. April 1867 (112–3).

CHAPTER XIV

TOPOGRAPHICAL SURVEYS: PUNJAB & NORTH-WEST

NORTH-WEST HIMĀLAYA: *Kāngra, Kulu, & Spiti, 1847–51 — Chamba, 1851–2 — Sutlej to the Ganges, 1852–4* — PUNJAB: *Hazāra, 1847–9 — Rāwalpindi & Jhelum, 1850–60* — PESHĀWAR, *1849–53* — DERAJĀT, *1855–60.*

WHEN Du Vernet's party was moved to the Punjab at the end of 1847 to take up the principal triangles of the North-West Himālaya series along the foothills from Dehra Dūn to Attock, it was specially organized "to form a complete military map of the mountain area to the north, on scale of 2 miles to an inch"[1].

During his first two seasons, Du Vernet carried his principal triangles westward from Banog to beyond the Beās in spite of interruption by disturbances in Hoshiārpur District [34–5; pls. 3, 6]. Meanwhile his assistants filled in the topography —supplementing the principal stations by secondary and minor triangles—through the plains to Jullundur and into the hills through Nāhan to Bilāspur [4–5, 118][2]. Special provision was made to connect with Blagrave's revenue survey that was being extended into the hill districts of Kāngra [7, 271–2].

The cis-Sutlej area was well-known, but not so the country beyond, which had formed part of Ranjīt Singh's kingdom. John Lawrence, Commissioner of the trans-Sutlej *doāb*, gives the following account of his charge [pl. 16];

> Bilaspore, or the Khyloosi chiefship, lies on both sides of the Sutledge, and is under the control of Mr. Edwards who resides at Simlah. ... All the districts north of the Bias, with the exception of Bilaspore, from the Sutledge to the Ravi, as well as Nadowri...south of the Bias, form the Kangra District. It comprises many large chiefships, such as Mandi, Sakeit, Mihal, Mori, Haripor, Chamba, in some of which the Rajahs exercise full internal sovereignty.
>
> All the lower range of hills from the Bias to the Sutledge, and that portion of the plains... included in a line drawn from one river to the other 10 miles south of Hoshiarpur, ... make up the Hoshiarpur District. ... The remainder of the doab forms the Jalandar District. ... The boundary between the Hoshiarpur and Jalandar districts is at present most irregular, but this will be remedied very soon, as the Revenue Survey has already passed over half the doab.
>
> The pergunnahs as they now stand, as well as their subdivisions or talookahs, are a perfect mass of confusion, and appear to have been formed with reference to the interests of the different parties who have from time to time held them. No trace of the old Mohamedan divisions of the country is now discernable[3].

The mountain area to be covered by Du Vernet's party stretched from Garhwāl to Chamba. The cis-Sutlej area, Garhwāl, Jhaunsar, and the Simla States[4], had been surveyed by Hodgson and Herbert some thirty years before [III, 29–44], whilst all that was known of the trans-Sutlej area came from the reconnaissance made by Cunningham and Broome in 1839 [IV, 269]. Now it was to be covered with an adequate network of minor triangulation carried out by experienced assistants of the Great Trigonometrical Survey and based on a main artery of the principal triangulation. The one drawback was that Du Vernet alone had any experience of plane-table survey, and that had been on the undulating Deccan plateau, a very different proposition from the mighty Himālaya.

For the second season's work, 1848–9, he directed that

> Messrs. Keelan and Dyer...will commence...at Bilaspur. They will ascend the Sutlej by Rampur to the British boundary near Shipki, and will thence...gain the sources of the river,

[1] DDn. 492 (58–71), SG. to Du Vernet, 12–6–47. [2] James and Owen Mulheran, Blewitt, John Dyer, Pierce, & Burt; MRIO. 7 (29), Hoshiārpur Dist. & States, 13–7–49. [3] DDn. 606 (14), Lawrence to Du Vernet, 29–9–48 [4] *v. Punjab States Gaz.* VI; *Simla Hill States*, pub. Lahore 1901.

and if practicable pass on to the boundary on the right bank of the Chapar, and the boundary stone between Lohul and Ladak called Phalong Dondee, and return to the plains by Tandi, the capital of Lohul. Mr. Mulheran with two other sub-assistant surveyors will also depart from Bilaspur with the same final destination. They will visit Mundee and Nadaon, and arrive at Tonda by the pass north of Sultanpoor. ... Two other sub-assistant surveyors...will traverse the country north and west, ... and triangulate the Ravi, Sutlej, and Bias, to Ropur[1].

Henry Keelan, one of Everest's most promising assistants, had started out by the hill route from Mussoorie, and was working north from Simla when he became alarmed at the prospect of survey in the Upper Sutlej valley during the winter months, and at his own inexperience with the planetable [422–3] ;

I commenced at...Banog, but not having had previous practice in this duty I found great difficulty in getting on with it. ... I arrived at the station of Bara Devi [Du Vernet's station 30 m. w. of Simla] on the 9th instant, and began the triangulation as well as the plain-table survey, but have not succeeded this time either, and I attribute the failure to my being a beginner in this new duty, and to survey so difficult a country without previous practice.

I shall proceed with the triangulation as far as I can with safety. I believed it impracticable to proceed above Rampoor with trigonometrical operations during the winter season. The mountains...are already covered with snow and...I anticipate being stopped in the work for a considerable time. ... I will esteem it a favour if you will be good enough to employ me elsewhere[2].

Though the Surveyor General was shocked at his lack of enterprise, Keelan was recalled from this unseasonable excursion, and employed on a secondary series from Rūpar westward along the Sutlej to its junction with the Beās, and then about 40 miles up that river.

Mulheran ran a chain of minor triangles, the Beas-Chandra-Bhāga series, from the principal triangles in the plains northwards into Mandi, where one of his signals was unfortunately fixed on a mountain top held to be sacred [471]. He later ran a route survey from the Jumna along the foothills of Nāhan, sketching the Jaswan Dūn and the northern boundary of Hoshiārpur[3].

The Deputy Commissioner of Kāngra described the hill areas of Kulu as being quite unsuitable for survey by Blagrave's revenue surveyors [271] ;

There is a district belonging to zillah Kangra called Kooloo, ... so mountainous, and the hills so grand and stupendous that it is impossible to delineate them on native maps. Kooloo is divided into three pergunnahs, one Kooloo proper, which is the valley of the Beas up to its source. On either side of the river is flat land varying from four to six miles broad, and then rising up on either side...to altitudes of 13,000 feet.

The 2nd pergunnah is Seoraj which lies between Koregurh on the Sutlej to the river Beas. This is also a fine mountainous country with hills higher on the average than Simla.

The 3rd pergunnah is Lahoul which is across the snowy range by the Rotung Pass. ... This is tableland like Tartary, with fine pasturage for sheep and plains of 10,000 feet elevation, and hills above covered with snow. Lahoul borders on Ladak [pls. 6, 16].

Such is Kooloo. The country...is divided into "kothees", which is the same thing as the Ladown tappas, each tappa containing 200 or more hamlets. ... I have ordered boundary pillars to be set on the limits of each kothee up to the levels of cultivation and habitation. It is useless to carry on the boundary pillars beyond the haunts of men up among the snows. Such a country defies the native aumeen. ... These hills can be surveyed all the hot weather[4].

Mulheran with Johnson and Blewitt triangulated in advance, taking the Bawarna series northwards to Mandi, observing 70 triangles and fixing the snow peaks on the Beās-Rāvi watershed. The planetablers worked on the ½-inch scale ;

Your assistants should be instructed to fill in the details to the utmost extent the scale will allow, omitting no important place or considerable village. If it is found impracticable to lay down every village, ... the smaller villages may be omitted, but...the value of the maps depends on their completeness as much as on their accuracy.

I have adopted the ½-inch scale as best suited for political and military purposes inasmuch as it gives a better general view of the country than a larger map, and appears to me amply sufficient for so wild a country, but the cultivation cannot be accurately shewn. ...

A country can be surveyed on the ½-inch scale in one fourth the time that such a survey would occupy on a scale of one inch per mile. For these reasons I would recommend that the

[1] DDn. 525 (25–7), to SG., 23-11-48. [2] DDn. 526 (325), to Du Vernet, 15-11-48. [3] *GTS. Syn.* VII (lii—C). [4] DDn. 526 (49), 23-3-49 ; *AJ.* LXI, 293, Nov. 1956, *Central Lahul* (279–95).

remaining portions of Sooket, Mundee, and Kuhloo be surveyed on the same scale as the southern portion[1].

Dyer and Talbot took up this ½-inch survey during season 1849–50, paying special attention to the inter-state boundaries. They completed 1,800 square miles of Kāngra, Mandi, and Nādaun. Blewitt and Johnson also ran several route surveys along the foothills between Rūpar and Pathānkot. Keelan was deputed to survey the Surveyor General's route through the Punjab from Hoshiārpur to Peshāwar [36]. There were other scattered planetable surveys, including the completion of Keelan's Mussoorie-Simla work ;

The upper mountain road from Masuri to Simla has been surveyed with the plain-table, but the work about Simla is not complete, the further prosecution...having been prevented by some of the party getting into a dispute with the villagers...which involved the whole party in the proceedings of the law courts [471][2].

At the end of 1850, Du Vernet handed over the principal triangulation to Logan and concentrated his whole party on topographical work. He sent some of his assistants into the lower hills at the end of October, but kept the others back to avoid the winter months in the higher hills ;

Before the month of January my assistants that are to be employed in the high range of mountains will be most beneficially occupied in bringing up the General Report. ... The parties taking the field at the present time will return...on the 1st of June, but the parties...taking the field in January will not return to quarters until November 1851[3].

He advised the Assistant Commissioner in Kangra that Mulheran

will return this season to complete the survey...west of the snowy range in the states of Kangra, Mundi, and Suket, and as the hot weather approaches he will ascend the mountains by the Beas-Riki Pass to survey the valley [of the upper Chenab] beyond the range on which the principal towns of Tanda and Triloknath are situated, ...

I myself, with a large party, will ascend the Sutlej by Rampur, and by Dankur in Kanawar pass through Spiti to the source of the Chandra River, and cross the mountains into Lahaul, entering the district at Chuhun Talso, one of the sources of Chundra Baga[4] [pls. 6, 16].

In pursuance of this plan, Dyer, Johnson, and Summers took the field in October 1850, and by the end of April had surveyed about 4,600 square miles on the ½-inch scale south of the snow range, covering the towns of Kāngra, Nādaun, Hoshiārpur, and Nūrpur, besides the stretch of the Sutlej valley between Bilāspur and Rāmpur. Dyer planetabled some 2,100 square miles covering Kasauli, Bilāspur, Rāmpur, and Simla "in a very satisfactory and talented style". After some weeks under instruction with Dyer, Johnson surveyed the vicinity of Simla, the sources of the Giri, and the Chaur peak [III, pl. 5].

Starting in March 1851, Mulheran extended the minor series northwards through Mandi to reach the Rohtang Pass in June, where he observed from a station at 15,124 feet. He then followed down the Chandra River to its junction with the Bhāga, and up that river to reach the Bārā Lācha Pass at the end of August [III, 43-4]. He then worked westward across the Chandra–Rāvi watershed and down the Rāvi to close on the principal triangulation south of Chamba, many of his stations being over 17,000 feet. He fixed Sultānpur, Triloknāth, Nūrpur, and many snow peaks, and sketched 3,500 square miles by planetable [pl. 6].

Meanwhile Keelan started from a side of the principal triangulation and took another series of minor triangles up the Sutlej to its junction with the Spiti, then turned north-west up the Spiti to the Parang-la range, crossed to the upper Chandra and linked up with Mulheran at the Bārā Lācha [234–5]. Several of his stations were over 18,000 feet, the highest being 18,400 [pls. 6, 10].

Dyer, George Shelverton, and James Peyton completed about 5,000 square miles of planetable survey[5]. Peyton worked up the Sutlej and to Dankhar fort on the Spiti, crossing the Manirang Pass from the south [III, pl. 5 rev. ; V, pl. 10] ;

The camping ground called Sangdo is indicated by a piece of level ground on the crest of a high ridge surmounted by crags, and overhanging a precipitous ravine. Here we found a

[1] DDn. 526 (19), SG. to Du Vernet, 23–10–49 ; 462 (345), to Bd. of Admin. 2–10–49. [2] DDn. 525 (270), Du Vernet to SG., 10–7–50. [3] DDn. 608 (25½), to SG., 5–10–50. [4] ib. (23), 6–10–50. [5] Total area detail svy. 12 mo., 13,740 sq. m. ; DDn. 565 (144), 23–2–52.

few Tartars who were sitting round a large boiling pot of tea, and near them were a few goats and sheep, the only animals used for the transport of merchandise. They were on their way to Sungnam, and had crossed the Manirang pass from the Spiti side without much difficulty. ...

A more frightful and desolate valley it is scarcely possible to imagine. As we approached the pass there was not a vestige of vegetation. ... Steep shingly slopes and rugged masses of bare rock. There was one glacier in the main valley, and on it our camp was pitched.

When we had gone about half-way to the summit, a mass of stones came flying over our heads from the rocks above. This was the advanced guard of a perfect storm of stones which descended with great clatter down the very edge of the glacier. ... The great rock now appeared as if broken into a series of pyramidical wedge-shaped masses ; at its base was a round space free of snow where I put up the planetable, and was able to send rays to the peaks on the Parang-La Range at the north-western limit of the Spiti valley [234–5]. ...

We found the sun perfectly hot, although...scarcely a thousand feet below the line of perpetual snow. I had the curiosity to take out my thermometer and lay it down on the shingle where the sun's rays fell directly upon it. It almost instantly rose to 110°[1].

Du Vernet describes the triangulation up the Sutlej gorge [pl. 10] ;

The secondary triangulation...has been advanced to this place by Mr. Keelan, and on the mountain east of the village[2], now covered with snow, there is a station. But the season is unfavourable for survey operations, and the continuance of snow on the hills overhanging the Sutledge is very embarrassing, reducing the sides of triangles to lengths of four or five miles, and greatly confining the breadth of the series and view of the upper mountain peaks.

On the 22nd of March when at Narkunda on the mountain ridge running east from Shali I visited the station of Hatugarh [III, 37]. It is not more than 12,000 feet above the level of the sea, but the whole route was through snow three or four feet deep, and in many places I met...drifts fifteen feet deep. ... Nevertheless the work has progressed, both as regards trigonometrical and detail operations, and the talent and steady perseverance of my assistants will surmount all...obstacles[3].

Success depended much upon rapidity of execution. The great range of the Himalaya had to be crossed and turned, ... and the detail survey of a frozen region to be effected in a limited time. The banks of the Sutledj are extremely precipitous, and from Rampur to Sarhan and Chini operations were much impeded by snow...so that it was difficult to select projecting rocks on which staves could be placed. ... The range once passed, uninterrupted serene weather and cloudless skies permitted the successful completion of the survey.

The grand chain east of Chini presents wastes of perpetual snow of great elevation and extent, and the lower grounds only, for about one thousand feet above the river, are habitable. It is on these between Chini and Sunam that the vineyards are met from which Simlah is supplied with grapes. ...

The entrance to the Spiti valley is very narrow, and the ground to the north-east much restricted for triangulation [III, 41–3 ; pl. 5 reverse]. ... The only track in Spiti follows the course of the river in a narrow valley. ... Above Dankar the...country...on the right bank is more open. ... .

The entire space between the Chandra and Bhaga rivers is one unbroken waste of snow-capped ridges and glaciers that never melt, and from the Bara Lacha to Tandi the left bank of the Bhaga is limited by precipices, and also the ground on the left bank to Triloknath, but the opposite side is inhabited, and provisions are procurable in Lahoul that failed in Spiti. ...

The triangles...are not symmetrical, ... which the impracticable nature of the country... rendered unavoidable. Barometrical and thermometrical observations have been made at various points to determine the heights of places situated in vallies. ...

Bridges consist of two trees laid across a river on corbels formed of trunks of trees, or hawsers of plaited sticks, or single ropes of loose cords on which the traveller is dragged across the stream lashed to a running tackle attached to a collar formed of a pronged stick. ...

In many cases stations 18,000 feet above the...sea have been ascended, whilst it was difficult to breathe in a recumbent position at the height of 12,000 feet. ... Though the climate of the vallies is temperate, that at the tops of the mountains is severe in the extreme, and...after toiling up a hill through melting snow the surveyor had to stand for hours with the thermometer at or below freezing point[4].

Du Vernet asked for special acknowledgement of Keelan's work. His stations between Rāmpur and Chini ran from 12 to 14,000 feet above the sea, and very much higher between Chini and the Bārā Lācha ;

[1] *GTS. Syn.*, VII, Peyton's narrative (lviii—C). [2] Sirnon, 12 m. of Rāmpur. [3] DDn. 606 (106), to SG., 11–4–51. [4] DDn. 593 (235), Report for 1850–1 ; 1–2–52 ; of SG.'s Report, 542 (262), 25–10–51.

The difficulty attending communications of all kinds. ... The helplessness of men from the plains, and even of the inhabitants of the country, upon hills of 17,900 feet such as that at the station of Lakhma near Shipki visited by Mr. Keelan, ... some men bleeding at the nose, and others overcome by giddiness and torpor, being incapable of any exertion[1]. The severity of weather at such great elevations and the difficulty of ascending them through melting snow, when at 14,000 feet the body appears too heavy to drag along on even ground, and it is difficult to breathe. ... The terrific precipices to be passed on most infirm footing ; torrents crossed on ropes and suspension or wooden bridges of frail construction and dangerous eminence. The risk of life and limb. ...

The highest peak of Nipaul is cited at 27,700 feet, but we have here a series of minor triangles 140 miles in length, ... the stations of which are from 14 to 19,300 feet above the...sea. Such an operation has never before been undertaken, and its successful termination...establishes for him a reputation as a surveyor of zeal, talent, and untiring perseverance[2].

The Surveyor General did not expect a high order of accuracy, and was quite satisfied that the surveyors had selected the best possible stations under "the appalling physical difficulties", but, to check accumulation of error along these long lines of small triangles, he suggested a number of astronomical observations [98, 286]. Even though these might be affected by "disturbed attractions" they would be interesting as throwing light on this "intriguing problem" [132].

Progress was eagerly watched by the Commisioner[3] ;

I look forward with great joy and exultation to the prospect of...obtaining a complete map of this division. How soon do you think it will be in your power to supply me with it ? Or at all events with the results of last year's work in Mandi and Kulu ?[4]

Du Vernet was not a magician ;

The Commissioner appears to have forgotten that there are two parallel valleys in Lahaul and to have overlooked the distance of that place from the Sutledge, and to have altogether over-rated the great powers of the Trigonometrical Survey. Before copies of my plans can be had, the fair sections on the half-inch scale must be drawn, and I hope the Commissioner will be content to receive copies from Captain Thuillier. That officer will combine them with the Revenue Survey's excellent maps of Collectorates. ... It will require another season to finish my detail operations[5].

CHAMBA, 1851-2

By October 1851, Mulheran had worked down the Chandra-Bhāga from Lāhul to Chamba, and reported direct to the Surveyor General that

the ground...is exceedingly difficult, but having become used to precipitous falls I am not so nervous as when I first commenced. I have finished 3,500 square miles of detail in addition to the triangulation, 224 miles in length, and should have liked very much to have finished all the low ground east and south of Chamba, but [have]...received orders to return. ...

A portion of the Pangah purgunnah in Chamba is very difficult, particularly the line for about 18 miles along the Chandra-Bhaga. The triangulation, however, if carried over the range north of Triloknath will...be as feasable and as safe as that already finished[6].

Du Vernet had himself reconnoitred westward into Chamba, and reported that the impracticable nature of the country on the banks of the Chandra-Bhaga between Triloknath and Sauch, the capital of the Pangai Taluk, rendered it impossible to conduct the triangulation in the direction of the river. In fact it was found that there was no path by which men could carry loads, and to reconnoitre the country I took...a north-easterly course and, ascending the Meyer River, crossed the Gurdar mountain by a very dangerous path and gained the Pangai valley [206 ; pl. 6, 11]. ...

The country north and south of the Gudar, also the country east and west of the snowy range forming the western bank of the Chandra-Bhaga, cannot be triangulated...except as regards the determination of certain identical mountain peaks of both surveys, and—whilst the detail operations and triangulation of Chamba below the ghats may be effected with almost the same ease as the country about Nag Tiba and Masuri, except as regards the parts immediately

[1] Du Vernet lists 12 stations between 17,343 and Kamalang, 19,424 ft. [2] DDn. 606 (137), Du Vernet to SG., 2-3-52 ; cf. visit to Spiti, Dr. James Gerard 1823 [III, 44 ; IV, 444]. [3] Donald Friell McLeod (1810-72) ; BCS. [IV, 486] ; Comnr., trans-Sutlej, from April 1849. [4] DDn. 607 (47), to SG., 21-5-51. [5] DDn. 608 (149), Du Vernet to SG., June 1851. [6] DDn. 606 (119), 25-10-51.

UPPER SUTLEJ

Part of quarter-inch degree sheet No. 9 drawn from half-inch survey carried out by the North West Himālaya Party under James Du Vernet, 1851–4.

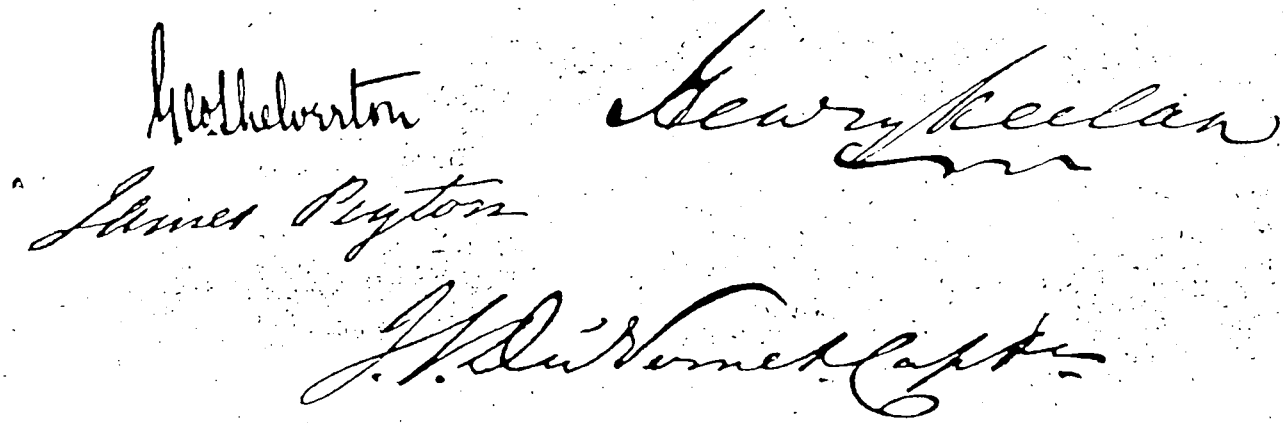
A notable chain of triangles was run during 1851 by Henry Keelan from Kasauli near Kālka, up the Sutlej to the Spiti junction, up the Spiti, and over to the Bāra Lācha Pass on the road to Ladāk.

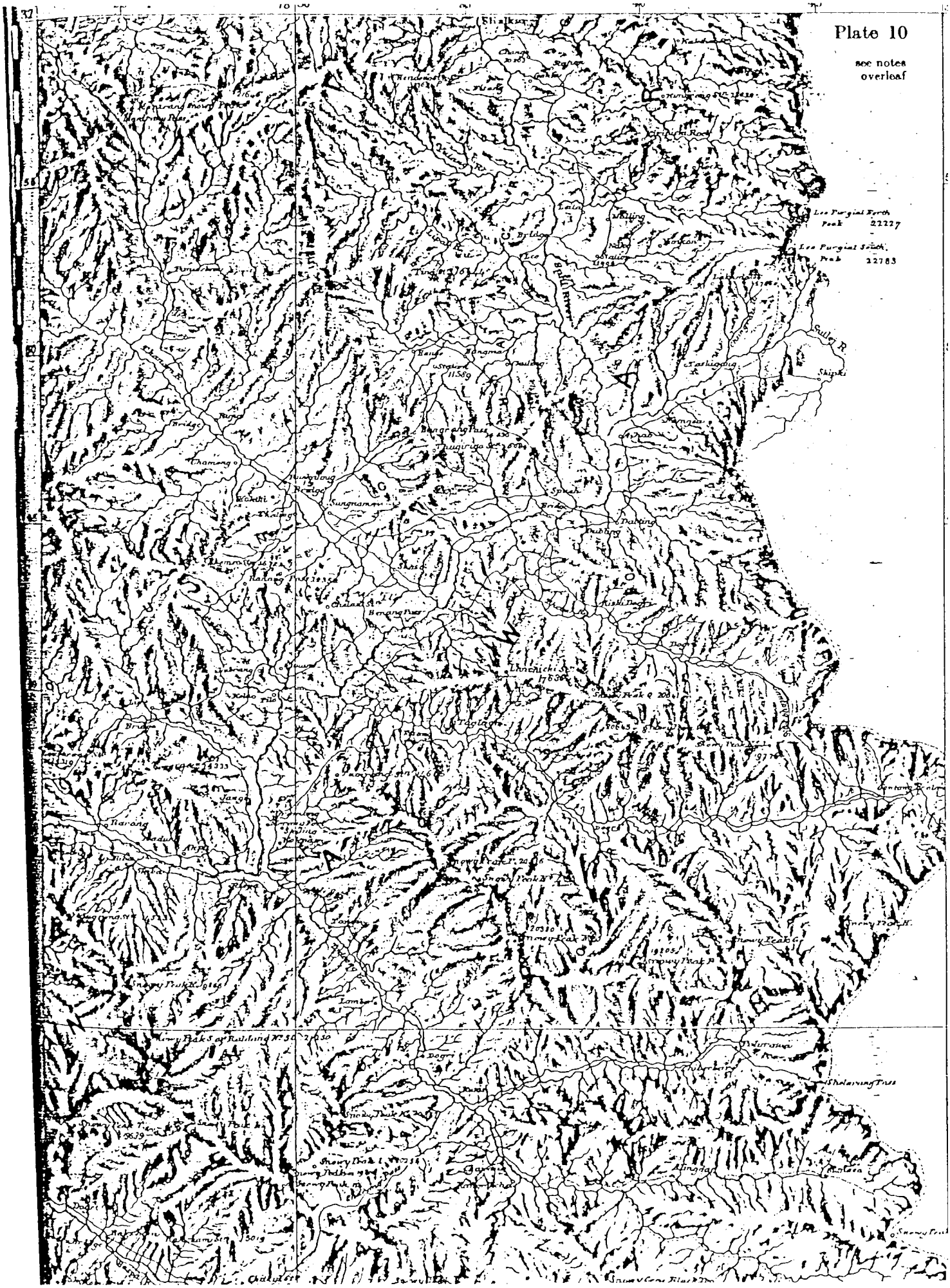
In 1854, after two failures, Mulheran, Shelverton, and Johnson took triangulation southwards up the Baspa valley and over the Great Himālaya to make connection with their work in the Upper Ganges valley to the south.

Planetabling on the half-inch scale was entrusted to Geo. Shelverton and James Peyton, and the latter gives a vivid description of his crossing of the Manirang Pass into Spiti, which both Herbert and Gerard had crossed in 1819 and 1821 [III : 41–3 ; pl. 5].

The fourteen quarter-inch degree sheets of this survey stretched from Garhwāl on the east to Chamba on the west [pls. 6, 11], and were drawn at Dehra Dūn during 1854. Outline by W. H. Scott, hills by Peyton, and hand-printing by Sheikh Ghulam Khadar.

They were reproduced by colour lithography at the Surveyor General's office at Calcutta under charge of H. M. Smith, and were awarded a medal at the Paris Exhibition of 1863.




Plate 10
see notes overleaf

below the great range—the Pangai taluk presents obstacles that will be found almost, if not altogether, insurmountable. ...

At Triloknath I ascertained the great extent of Chamba above the ghats, and that the boundary extended northerly to Darwas on the Chandra-Bhaga, ... and easterly to the great snowy range which runs parallel to the river at distances of from twenty to thirty miles. ...

Detail operations in Spiti will be completed this season, and in fact all detail work within the Kangra District, and...the triangulation of Chamba below the ghats being effected, I shall be better able to judge of the practicability of conducting operations in Pangai. ... There remains...in Chamba sufficient to occupy one triangulator and two detail surveyors for a season[1].

The Surveyor General deprecated this pessimism ;

I am not aware whether Mr. Mulheran has been able to complete the Pangai pergunnah in Chamba which Mr. McLeod wished to be included. ... The difficulties are described to be great, but, as Napoleon argued in the case of Marshal Macdonald's operations in the Alps, where a goat can go, a man can go, and where a man can go, a soldier can carry his musket.

With such high authority...there is every reason to conclude that a surveyor would be able to operate with a small 5-inch theodolite and a planetable. At any rate nothing is impossible which has not been tried [t-page], and I trust Mr. Mulheran will have succeeded[2].

To speed the survey Du Vernet suggested that Dyer should complete detail survey "below the ghats" and Peyton that "above the ghats", leaving Mulheran to confine himself to the triangulation ;

I do not propose that he should have anything to do with taking up detail, being thoroughly convinced that the detail requires the whole undivided attention and best energies of a surveyor and that it is impossible for a man to do justice to plain-table work when hampered with triangulation, and vice versa.

He thought that the area below the *ghāts* would be finished by the end of June 1852, and that above the *ghats* by "some time in September and October". He recommended that the map be drawn in half-degree sections[3]. The Surveyor General agreed that smaller field-sections would allow more room for the plotting of exterior points, but did not like the distribution of work ;

It is a great advantage when practicable to employ surveyors on the localities they are best acquainted with. ... Mr. Mulheran is the most suitable persons for completing the survey of Chamba, above and below the ghats. This tract is contiguous to his past season's operations. ... Mr. Dyer being familiar with the hill country east of the Sutlej over which he has in fact chosen the preliminary stations, it would...be a great loss to remove him from a locality with which he is so well acquainted. ...

As a general principle, no doubt, there are advantages in division of labour with regard to triangulation and plain-tabling. ... Last season Mr. Mulheran had an immensely extended field to survey ; ... division of labour would have been most advantageous, ... but now, when it is only proposed to extend the survey over a small rugged tract, it appears to me that there is hardly sufficient scope for the employment of two persons[4].

Mulheran was accordingly left alone during the summer of 1852 to carry out the triangulation and topography of the Chandra-Bhaga valley which forms the northern division of Chamba known as Pangai. ... Pangai is bounded on the north by the Zanskar snowy range in Ladakh[5], by the district of Kishtwar in Kashmir on the west, and by Lahul and Chamba proper on the east and south.

The two streams, Chandra and Bhaga, rising in the Baralacha Pass unite at Tandi, from whence under the name of Chandra-Bhaga the river flows westward, ... entering Kashmir territory west of the Sachi Pass [pls. 6, 11][6].

He commenced triangulation on 26th April at a principal station, height 2,785, on the bank of the Rāvi some 10 miles north of Pathānkot, and reached the Sachi Pass by 27th June. The higher summits on this range which runs south of the Chandra-Bhāga rise to 17 and 18,000 feet [pl. 11] and he had taken the precaution...to intersect all the snowy peaks likely to serve as points in crossing the range. I then returned south-west in the direction of Kairi to complete the planetable sketch of the tract bounding Bisoli. I observed from Raonair all the snow peaks intersected from Randhar, particularly noticing the point to be occupied above Sanchi in crossing the range. From

[1] DDn. 606 (19), to SG., 24–9–51. [2] DDn. 591 (138), SG. to Du Vernet, 7–11–51. [3] DDn. 606 (122), to SG., 20–12–51. [4] DDn. 591 (52), 9–1–52. [5] on modern maps Zānskār Range lies north of Great Himālaya Range, which latter bounds Pāngi from Ladākh ; v. Burrard & Hayden, frpce. ; chart xvi, fig. 2 ; Mason, figs. 3, 4 : 1/2 M. *SA Ser. Kashmir.* [6] then becoming the Chenāb R., *GTS. Syn.*, VII (lxii—C).

Raonair I proceeded to the Daderwa Pass, and after completing the sketch of the western boundary of Chamba returned to Himgir. ...

From Tisa there are two routes to the Chaini Pass, that known as the 'Raj Rasta' runs over some broken ground above the left bank of the river, ... in moving across which my foot slipped, and I was precipitated over a rock and very severely shaken, from the effects of which I suffered for a considerable time. ...

I reached the Sachi saddle...on the evening of the 3rd day, and after selecting the most sheltered snow-bed to pass the night, proceeded...to cut a path to the hill, ... which after much toil and distress I reached at noon the following day, but owing to unfavourable weather was unable to obtain a sight of either Rundhar or Raonair. ...

Shortly before sunset I obtained two intersections to Himgir. I retired for the night to the shelter of the inner fly of my shouldari[1], already occupied by most of the people who had accompanied me. The following morning I was too unwell to stand without support, and could not, had the weather been favourable, have moved round the instrument, which...was within 3 feet of a precipice 2,000 feet deep.

He abandoned this station and worked towards the north ;

The day after my arrival at Sanch I visited the station on the snowy spur above Bataor [pl. 11], near which I was detained 9 days by unfavourable weather accompanied occasionally by sleet and snow, during the whole of which time fuel was procured from...several thousand feet below the station, and in quantities quite insufficient for the...people, protected only by a blanket and such cover as projecting rocks and two darries[2] afforded them.

Although I had failed...to determine the positions of the great peaks in the Zanskar Range, the weather was so unpromising, and the men so dissatisfied with what they had already undergone, that I considered it prudent to leave unfinished what remained. ...

At Bataor I was detained 3 days by rain, but as I was suffering from an attack of blood piles and had run short of provisions, the detention was far from unpleasant. ... From Bataor I marched to the bottom of the glacier under Gurdhar, and after a further detention of 2 days moved on towards the pass. ... Whilst seated on the ridge watching the approach of the instrument, one of the hill porters lost his footing while moving across a ledge 8 inches wide, and was for a time suspended by the pole attached to the instrument box he was carrying. For several moments I was afraid that man and box would have rolled over the precipice, but providentially the leading men with the tug rope retained their hold until assistance was afforded.

After waiting 2 hours on the ridge to collect stragglers, I proceeded along the edge of an old glacier to a spot free from snow, taking as much wood as I could carry from the supply collected near the pass. Early next morning I proceeded to the station which I reached a little before 12. The weather being unusually favourable I completed...after 3 p.m., and returned to my tent at sunset, most of the people, however, suffering from inflamed eyes caused by the reflection from the snow, for which a little honey, recommended to me by the Tartar guides, I found an excellent remedy [207, 223].

Having completed the survey of Pāngi Mulheran worked his triangulation south-east-ward through Triloknāth to Bangahal, and thence marched via Mandi, Balaspur, Dagshai, and Nahan, to Dehra, which place I reached on the 15th November after an absence of 8 months during which I completed 2,700 square miles of planetable detail in addition to about 1,072 square miles of triangulation, at an average cost of Rs. 1·2 per square mile[3].

SUTLEJ TO THE GANGES, 1852–4

In November 1851, survey was resumed between the Sutlej and the Ganges in the lower hills where work was possible during the winter months. Dyer triangulated the Simla Hills, whilst Summers took up the ½-inch planetable survey of the hills north of Rūpar and Kālka which had previously been sketched on the ¼-inch scale. During the summer months Keelan carried a series of secondary triangles eastward from Banog to cross the Bhāgīrathi into Tehri-Garhwāl. Peyton planetabled across the basin of the Tons and the hills of Jhaunsar Bawār, or Chakrāta, east of the Chaur [III, 31–2 ; pl. 5], covering the higher portion of the ridge north of Deoban, far beyond the limit of trees and track of

[1] *shuldari* = two-pole tent. [2] *dari* = cotton rug. [3] DDn. 593 (321), Mulheran to SG., 11–4–53; *IO Cat.* (257), 4 sheets, 2 m. to inch.

North-East CHAMBA

Slightly reduced from north-east sheet of CHAMBA TERRITORY, compiled on half-inch scale from original field-sections surveyed 1851–2 by James Mulheran of the North-West Himālaya party under Major Du Vernet [ch. xiv]. Photo-zincographed Dehra Dūn, March 1872.

Covers part of PĀNGI and CHAMBA LĀHUL falling in sheets 18 and 19 of plate 6 of this volume, which correspond with modern degree sheets 52 D and C; Chamba city lies some 20 miles to south-west.

see notes overleaf

△Badail St
12930

△Rock N
18645

△Snowy Cone Great Range
18180

Shune St

△Sauch St
13822

Sauch
1886

Shune
8412

△Chasag St
12875

Snowy Cone
17219

△Dahaul St
16523

△Batadr St
16884

Station B△

Gurdhar Great Snowy Mass
21142

Pharang Kh
12142

△Gurdhar Needle Rock
18246

Snow Peak

Gurdhar St
17250

Miyar St

Miyar
10215

△Karpat St
14689

△Snowy Peak
20658

△Chimrat St
15617

△Chimrat Snowy Peak
20257

Glacier

Glacier

Glacier

tourists. The view of the snows at the head of the Jumna and Tons valleys, and of the terminal peaks defining the southern limit of the Sutlej valley, is very fine from all prominent points on the Deoban range, ... especially from Kidarkánta station, 12,512 feet [III, pl. 5; V, 81].

Chaur Peak, 11,966 feet above the sea, "stands up above the surrounding ranges like a huge beacon", visible from Simla on the west and from Dehra on the east, and snow-capped to the end of June. No point within sixty miles approaches within 1,500 of its height [IV, 435; V, 137].

Shelverton surveyed the upper Jumna and sketched the southern face of the great range from Banderpūnch to the Bhāgīrathi watershed.

By the end of 1852, there remained only the valley of the Dūn and the Siwālik range, and the valley and headwaters of the Bhāgīrathi. The opportunity was taken to transfer Du Vernet to charge of the Assam Longitudinal series of principal triangles [29, 393] leaving Mulheran in charge of the Himālaya survey, with Dyer, Peyton and Shelverton to assist. During the cold weather of 1852–3, Shelverton and Peyton ran a series of triangles along the Siwāliks from Hardwār to close on the ridge west of Banog. Peyton records that

at the time the survey was made, tigers and wild elephants were common in all the forests covering the Siwaliks. When Mr. Peyton was camped about 4 miles below the head of the Motichur Rau, near a cluster of huts, the woodcutters occupying them were afraid to move a hundred yards after sunset on account of the tigers. The district is not so wild now, sportsmen, forest rangers, and cattle having routed the quiet of the primæval woods[1].

During the summer of 1853, Dyer extended planetable survey over Tehri-Garhwāl north-east of Mussoorie, and then triangulated up the Bhāgīrathi, but failed to carry through the Gangotri gorge. After the rains another attempt was made to connect with the triangulation of the Upper Sutlej, Mulheran working from the south and Dyer and Shelverton from the north, but heavy snow defeated them. Shelverton describes his brave attempt from the north;

I reached Lanchichi in the Buspa valley [III, pl. 5; V, pl. 10] on 30th September, venturing...along an unfrequented path, the steep ascents and descents of which lay along the most fearful precipices. The station was a very favourable one for work. I measured angles to seven peaks, most of which I thought would be visible from Themso.

I arrived under Themso on the 4th October when the expected storm burst and snow fell unremittingly for four days. I had chosen Runang Ghat for my encamping ground, an elevation of 14,000 feet; my tents were all but buried in snow, and in this uncomfortable situation I was obliged to remain till the 10th, when I took advantage of a break...and attempted to force my way to the staff. I had hardly accomplished half the distance when the whole hill was enveloped in mist, and we were compelled to retrace our steps. The men...suffered severely, and the snow affected my eyes to such an extent that I was perfectly blind for two days, and experienced excruciating pain [223].

On the 14th I made a second attempt, and succeeded in reaching the staff after toiling over soft snow and a difficult ascent of six miles, but not before the clouds had again shut out all the peaks that I had seen from Lanchichi H.S. I...uncovered the station mark and set up my theodolite, ... but I soon found that I could not remain any time on the hill with safety. A high, cold, cutting wind had set in...and was blowing the fresh snow sharp against our faces. ... My fingers were numbed. ... I could not level my instrument. My men were complaining bitterly, most of them positively crying, and as there was not the slightest chance of finishing the observation of my angles, I hastened down to my encampment, ... giving up...all hope of triangulating the Nisang and Khun valleys. The whole party...was again snow-struck, and two of the men frostbitten, one so very severely that...he will be crippled for life. I left Sangla on the Baspa...the 21st of October 1853[2].

Mulheran's work from the south had been equally disappointing;

I was obliged to retire from the Nela Pass in October, the heavy falls of snow on the 5th, 6th, 7th, and 8th of that month rendering the route across the fissures of the great glacier on the northern face of the ridge extremely unsafe, if not impracticable, for either men or sheep. Messrs. Shelverton and Dyer, who had entered Kanawar in September and commenced the survey of the Baspa and Charang valleys, were also obliged to retire, the flagmen in advance being unable to occupy the points required[3] [pl. 10].

[1] *GTS. Syn.*, VII (lxii–iv—C). [2] DDn. 606 (96–103, 165), Shelverton to Mulheran, 25–10–53.
[3] DDn. 609 (177), Mulheran to SG., 11–11–54; Kanāwār, upper *pargana* of Bashahr State [III, 40–3; pl. 5].

Mulheran and Shelverton spent the cold weather 1853–4 on the Chach base-line, Dyer being transferred to Robinson's party, and in the spring Mulheran brought Johnson back to complete the connection from the north. They marched up the Sutlej valley during March, and broke into two parties at Chini;

From Chini I detached Mr. Johnson to triangulate the Baspa valley, proceeding myself towards the Rishi, Nisang, and Charang valleys, previous to entering which I visited the stations of Themso...and Lanchichi, and intersected all peaks visible, ... in addition to...points... for basing the planetable detail. ... The Gangtang, Kubrang, Sholarang passes were either crossed...or sketched from points commanding an uninterrupted view. ...

Previous to Mr. Johnson's visiting Khurgu and Mahlale, I proceeded from Makun with 20 maunds of atta and other supplies towards the Jhela Kanta Pass, intending to furnish a sketch of the entire tract east of that pass, but, ... the Tartars had received intimation of my approach, and had expressed strong objections to my making a survey of any part of their territory. I considered it prudent to return without finishing what was required.

On the 13th of May Johnson commenced at Rakchora of [Keelan's] Sutlej...series. Triangulation was pushed...through the centre of the Baspa valley—one station 18,338 feet, another 18,683 feet—...The Nela station [19,086] is on a pyramid...of broken masses of white granite forming the apex of the mountain above the pass. This was the peak that for two seasons challenged the mountain climbers of the...Himalaya series. On the 22nd June it was ascended by Mr. Johnson, and his observations from the summit realized the results desired. ... Johnson descended into the Bhagirathi valley [and] observed from the stations of Mahla and Khargu of [Dyer's] Bhagirathi series[1].

Thus was the field work of the topographical party of the North-West Himālaya survey brought to a close. Computations and mapping were completed at Dehra Dūn, after which Mulheran was transferred to charge of the Hyderābād survey. In April 1855, Johnson marched the party from Dehra Dūn to place it under the charge of Montgomerie to start the survey of Kashmir [221–2].

The narrative of the magnificent work of these seven years was written up in worthy style by James Peyton[2]. The survey was reduced and mapped on the ¼-inch scale in 14 degree sheets lying between parallels 30° and 33° 5′, and between meridians 75° and 79° 10′—the Jammu border on the west to Hardwār on the east. These were lithographed in colours at Calcutta in 1860 [318–9, 330–1 ; pl. 6 n.][3]. Mulheran's survey of Upper Chamba was photo-zincographed in colours at Dehra Dūn in 1872 [pl. 11][4].

PUNJAB : HAZĀRA, 1847–9

The district of Hazāra lies to the west of Kashmir and runs from the Kāgān valley on the north to Haripur on the south. In 1846, after the 1st Sikh war, it was assigned to Gulāb Singh with Kashmir, but passed to the British in 1847 in exchange for land near Jammu [220]. James Abbott, a former revenue surveyor [IV, 416–7], held charge from 1847 to 1853, leaving his name to the headquarters station, Abbottābād [187, pls. 5, 16].

In 1847 Abbott was Commissioner for settlement of the south boundary, having Daniel Robinson and Ralph Young as surveyors. In August Robinson was appointed to make a "military survey" of whole district[5]. An ample staff was sanctioned —two European assistants [423][6]—three Indian surveyors—50 *khalāsis*. Instruments were a difficulty, but a 4-inch theodolite was procured from the magnetic observatory at Simla [IV, 118–9] and, writes Robinson,

I...procured from England at my own expense a 6-inch theodolite with two telescopes, by Jones. ... The standard steel chains did not arrive until long after I had measured my base, and the 6-inch theodolite and artificial horizon only in time to fall into the hands of the Doorāneēs[7], who plundered our baggage and all instruments except one 4-inch theodolite, two telescopes and two prismatic compasses in February 1849. ...

[1] DDn. 609 (177), Mulheran to SG. 11-11-54; also reports for 1853–4 & 1854–5; DDn. 443 (15), 549 (159). [2] *GTS. Syn.*, VII (1-lxxiii—C). [3] *IO Cat.* (239); MRIO. 6 (28-41); *GR. Topo., 1859–62* (19). [4] *IO Cat.* (227); MRIO. Misc. [162]. [5] OO. GG., 12-8-47. [6] W. Llyod. resd. within one month—James Scott Ingram, b. Bareilly, 15-5-29, son of Capt. J. W. Ingram (1794–1838), Ben. Inf. [7] Afghān.

We marched from Wazirabad on the 20th of October...via...Hasan Abdal. ... We made route surveys of the country right and left of the road. They...were the only maps that could be depended upon when that country became the seat of war in 1848–9.

From Hasan Abdal we marched to the level plain of Chuch [42 ; pl. 7] to measure a base-line. ... As the standard chains had not arrived, and there seemed to be no chance of their arriving for many months, I was obliged to use common Gunter's chains, and two ten-feet deal rods compared with a 2-foot Gunter's brass scale.

After measuring the base, just over 5 miles long, they commenced triangulation in January 1848. On the outbreak of the 2nd Sikh war in May

all officers on detached duty were called in to military stations. ... We...were ordered to join Major J. Abbott at Huripoor, and from that time until the conclusion of April 1849 we were employed on other and military duties. When I discontinued surveying in May 1848, I had done but a small portion of the triangulation and sketching of eastern Hazara, and when I returned in April 1849 I was ordered by Colonel Napier[1] to do all that I could before the commencement of the hot weather, and then...to return to Lahore. ...

Being extremely anxious to complete Hazara...I remained in the field throughout the rainy season, when I marched to Lahore. ... I was shortly after attacked with rheumatism which confined me to my bed from 18th November to the middle of February. ... [I] could not complete the map till the end of May 1850, when it was at once sent to the Board of Administration at Lahore. They kept it for nearly a twelvemonth, and it was then sent to the Deputy Surveyor General at Calcutta, who sent it back to me again last year [1853] that I might recompile it on...the Great Trigonometrical Survey[2].

According to the Surveyor General's account,

Lieutenant Robinson's early labours exhibited considerable talent and enterprise, but being badly equipped with instruments, inexperienced in extensive survey operations, and left to his own resources, he had much to learn, and a good deal to unlearn. Nevertheless as he possessed energy and a great taste for drawing ground, which is a rare talent, I considered him an acquisition to my Department[3].

In September 1853, after Robinson had made good progress on the survey of Rāwalpindi District under the orders of the Surveyor General, his original sketch of Hazāra, scale 2 miles to an inch, was returned to him for revision and adjustment to Logan's triangles [36–7]. The south-east corner of Hazāra which had been transferred to Rāwalpindi was now properly triangulated and surveyed on the one-inch scale [210][4]. The distant country of Kāgān was added to the map ;

Circumstance did not admit of my visiting the wild country of Kaghan in 1848–9. Since then that valley is much quieter, and Lieut. Peter Lumsden, D.A.Q.M.G., was last year able to make a reconnaissance to the head of the valley, and from the...mountains overlooking Chelas he obtained a view of the country on the Indus...which no European had ever before seen. ... The revised map...has been projected on the basis of the Great Trigonometrical Survey. ... Five triangles were observed by Mr. Assistant Carty and myself with two twelve-inch theodolites, which...embraced all the most important of my old stations[5].

So urgent, however, was the local demand that 50 "preliminary" copies were lithographed at Calcutta before adjustment to the trigonometrical survey[6].

RĀWALPINDI & JHELUM, 1850–60

At the end of 1849, the Board of Administration at Lahore [272 n.3] asked that Robinson should extend survey through Rāwalpindi southwards and westwards to cover the whole trans-Indus area under British administration as far south as Mithankot. For such an extended survey they asked that he should be placed under the orders of the Surveyor General, to whom they wrote ;

As Hazara and most of the country down to the Salt Range has been surveyed, and as Lieutenant Walker...has done most of the Peshawar District, the Board would like to see Lieutenant Robinson engaged upon the completion of the survey down to the Salt Range,

[1] Robt., 1st Baron of Magdala (1810–90) ; Ben. Engrs. ; Civ. Engr. Lahore, 1849–56 ; *DNB.* ; *DIB.*
[2] DDn. 533 (1–12), Report. 1–12–55. [3] DDn. 649 (63), to Mil. Dept., 19–9–53. [4] Svy. by John Dyer, MRIO. Misc., 26–0–56. [5] DDn. 533 (9–10) ; 580 (172), Jan. 1854 ; Map, 4 sheets, *IO Cat.* (249) with Report, 1–12–55 ; MRIO. 5 (17), Misc., 18–0–55 ; 2 m = 1 inch. [6] DDn. 624 (106), 5–4–56 ; cf. DDn. 459 (2), W. R. Hodson offers to pay cost of MS. copy, 24–12–52.

including its hills, and then to cross the Indus at Kalabagh and work over to Bunnoo, and ...down the Indus and Derajat to Mithunkote. ... Kohat, the only dangerous quarter, will be ...taken up by Lieutenant Walker a year or two hence when affairs are more settled [216].

Lieutenant Robinson has no assistant surveyor, but the Board hope that he will be furnished with at least two or three assistants, ... and with good instruments. ... The Board would further be obliged by...a chain of triangles run across the Baree Doab to verify their surveys...under the Civil Engineer[1], ... and the revenue surveys about to begin [272].

Robinson was thereupon transferred to the Surveyor General's orders in July 1850, and a new party raised with Talbot from the Himālaya party and Joseph James and Platts newly recruited [423]. Their first task was to survey the boundary between Māhārāja Gulāb Singh's Jammu territory and the British districts west of the Rāvi River [pls. 1, 16];

Mr. Logan's great triangulation occupied the same line of country, so that Lieut. Robinson's operations proceeded in connection therewith, and he had an opportunity of learning geodetical duties. ... The postponement of the survey of the Salt Range was advantageous, as it enabled the G.T. Survey to furnish...a good basis by which...greater...efficiency has been secured[2].

Robinson left Dehra Dūn with Logan on 7th October 1850 [36], and started work on a minor series breaking out from the principal triangles, whilst his assistants ran a traverse line along the actual boundary from the neighbourhood of Pathānkot. Though Platts was down with fever most of the season and James had the misfortune to break his collarbone, work was brought to the Jhelum R. by 17th May and the party returned to Dehra on 8th June.

The southern boundary of the Jamoo territory from the revenue survey triple-junction pillar at Madhoopoor near Shoojanpoor on the Ravi to the fort of Mangla at the point where the river Jhilam debouches from the mountains [pl. 12] is defined by a series of boundary pillars of pukka masonry from 6 to 9 feet high. ...

Half of these pillars were built by Maharaja Goolab Singh and half by the Lahore Durbar, ... the whole number...being about 2000 in a distance of about 260 miles of tortuous boundary, or 160 miles as the crow flies. Whenever a portion of a river defines the boundary an extra large pillar...is placed at the point where the boundary line reaches the river. ...

This traverse, 260 miles in length, was checked throughout by secondary points from my triangulation (made with the 12-inch theodolite), having sides from six to twenty miles in length, and this triangulation was checked again by...the North West Hill series, from a side of which it emanated and upon a side of which it closed[3] [36–7].

During season 1851–2 Robinson started survey of the area between the Jhelum and Indus rivers, overlapping the southern limits of his Hazāra survey to the north ;

Having ascertained [writes Waugh] that the skirts of the Lieutenant's former military survey of Hazara which overlapped part of Jhelum and Rawalpindi was...mere sketch work, unfit for incorporation with the Atlas [214], I considered it expedient...to extend the undertaking over the whole of the Rawalpindee and Jhelum districts so as to produce a final and complete survey of those rugged tracts, so important in a military, political, and geological point of view, and so interesting from its variety and peculiarity of configuration.

The time was most propitious...because the whole district was being traversed by the great triangulation. Moreover the survey of Derajat was not pressing on account of the politically disturbed state of the frontier[4].

The survey was on the one inch scale [214, 289] and soundly based on Logan's principal triangles[5]. The party left Dehra on 11th October 1851, and reached Jhelum on the 18th November, having accomplished the march of 400 miles in 38 days, including halts and 2 days delay at Umballa for medicines and change of carriage. On the march the whole party were employed in making duplicates of last season's angle books.

Resuming triangulation in the hills west of Jhelum, Robinson had sufficient points computed and plotted to start his planetablers by 23rd February ;

Observations have been taken from 17 principal stations and 14 first-class secondary stations. ... More...would have been done had I not had to devote some valuable time to computing and planetabling. ... The area triangulated and covered with poles or signals at 2 to 4 miles apart is about 3,400 square miles.

[1] Canal svys. in progress 1849–53 [68 n. 5]; MRIO. Misc., 13–0–49 ; DDn. 467 (134), 11–7–49 ; 541 (182–4), 27–5–50. [2] DDn. 549 (63), SG. to Mil. Dept., 19–9–53. [3] Report, DDn. 593 (297), 1–8–51 ; maps, MRIO. Misc., 9 & 12–0–51 ; Rāvi to Jhelum, 1-inch to m. ; *IO Cat.* (256), ½-inch reduction. [4] DDn. 549 (63), SG. to Mil. Dept., 19–9–53. [5] DDn. 591 (124), SG. to Robinson, 24–10–51.

Mr. Talbot failed from impatience; his zeal and activity were very great, and had he done half well instead of the whole indifferently, his work would have been satisfactory. The area of his survey, about 700 square miles, ... must be done over again.

Mr. Joseph James worked exceedingly hard, but could only complete half a planetable. His work is, however, first rate and superior to anything of the kind I have ever seen before; the goodness amply compensates for the shortness in quantity. ... I was unable to do more than 50 square miles of planetabling myself. ...

Mr. Platts was employed entirely in my office, and in selecting stations. He has very superior abilities and is a first-rate computer and recorder[1].

Field work was closed during May 1852, when the party assembled for recess in Murree. The survey of the trans-Indus area having been dropped [210], designation was changed in October to the somewhat cumbersome title of "Topographical Survey, Bengal Establishment, No. 1" [363]. Strength was increased by the posting of Andrew Chamarett, whilst Talbot's resignation was met by the posting of John James, of the notable survey family, who was to prove a tower of strength as planetabler and draughtsman. The Surveyor General pressed for the highest standards of accuracy and draughtsmanship;

The survey of the Jhelum and Rawal Pindee districts...is progressing steadily but slowly owing to the intricacy of the ground and the high standard...aimed at. I drew up for this work a very minute code of Instructions, which is now being printed at Roorkee by order of the Hon'ble the Lieutenant Governor [213, 282]. ... The map...gives every promise of being the best topographical survey yet executed in India, and I have spared no pains to make it so. By the end of this year I shall be able to visit the party in the field on my way to measure the Chuch base [42–3][2].

In his report for 1852–3 Robinson describes his crossing of the Salt Range;

The old bases of triangulation were from 16 to 18 miles, and the width of the Salt Range averages about 8 miles. It is impossible from the northern flank to see...into the plains beyond and, the south flank being lower than the northern, stations on it could not of course see stations to the north of the range. The only chance of getting a symmetrical series was to get stations on the higher peaks of the lower steps, so as to see the higher stations on the northern flank through gaps in the intermediate steps, and also to see the plains beyond. ...

[Of the planetabling] Mr. John James had completed 374 square miles of first class work. Being new to the work, and the country...being a mass of most intricate ravines, he could not have done more without sacrificing much valuable detail.

Mr. Joseph James completed 350 square miles of equally good work. Mr. Chamarett 377 of very fair work indeed. ... I myself completed 20½. ... Total 1,266 square miles. This is doubtless a very small season's work, but the nature of the country admits not of rapidity of execution without the sacrifice of accuracy and detail. ... Throughout the districts of Rawal Pindi and Jhelum the whole of the country north of the Salt Range is cut up by most intricate ravines, which can only be developed by patient, careful, surveying[3].

There were several changes during season 1853–4; Joseph James resigned and John was absent several months on the Chach base-line. James MacGill died. Shelverton and Dyer joined from the Himālaya party and received personal instruction from Robinson. Hörst and Bell were newly appointed during recess.

During 1854–5 the question arose as to whether a regular revenue survey party should be brought in, or whether Robinson's survey would suffice for revenue purposes [284–5]. The Chief Commissioner asked whether

the boundaries of thanas and tehsils can be defined in the topographical survey maps, provided such boundaries are marked on the spot before the survey commences, or...during the progress of the survey in conference with the topographical survey. ... If they cannot, and if a revenue survey be further necessary, then a question seems to arise whether it is necessary that the Government should be put to the expence of a scientific topographical survey as well as a revenue survey. It appears superfluous to have both[4].

Robinson pointed out the difficulty of surveying boundaries in an unsettled area;

I have endeavoured to shew as accurately as possible, not only the physical features of the country, but also all well-defined roads, the cultivated and waste lands, and tehsil and district boundaries. It was also my intention to have shown...[lesser] boundaries, but...until

[1] DDn. 593 (287), Report, 1851–2, 1–9–52. [2] DDn. 549 (60), SG. to Mil. Dept., 28–6–53. [3] DDn. 593 (437), July 1853; *IO Cat.* (256), pt. sketch by John James, Jammu, 1852. [4] DDn. 548 (64), to SG., 10–2–55.

some regular settlement is made this is impossible. Even in the district and tehsil boundaries there are great difficulties. ... Even when the boundary was not disputed the surveyors were dependent for accurate information on an ignorant burkandaz deputed...from the tehsil, but as no previous steps had been taken to show the burkandaz the boundary, the surveyor knew almost as much about it as the burkandaz. ...

That these boundaries have not been laid down is not the fault of the surveyors. ... At any time, now or hereafter, roads, canals, boundaries, anything that the scale would show, can be easily laid down, provided only that my survey marks remain intact. I have marks consisting of masonry platforms and poles covered with straw. ... These poles and brushes are constantly stolen or destroyed ; indeed, immediately round Rawalpindee they are destroyed almost as fast as they are put up. I have in two or three cases discovered the offenders and prosecuted them, but the trouble...of sending...witnesses into cantonments for that purpose is so great that I have...to put up with the lesser inconvenience of losing my marks. ...

Laying down thana and tehsil boundaries :— the expense...would be very trifling and, compared with the expense of a revenue survey in such a country, nothing, for it is difficult to conceive a country in which a revenue survey would meet with greater practical difficulties[1].

Whilst it was decided not to employ a revenue survey party for the present [285. pl. 16], Robinson records that the settlement officers were furnished with copies of all the planetable sections. They speak most highly of the accuracy of the maps, and the great assistance they are to them. ... The Settlement Officer of the Jhelum District, having requested me to assist in checking his polwaree thakbasts and shruddas, I agreed to lay down all his trijunction pillars if he would mark them with a white-limed ghara on the top of a pole [IV, 90]. This he did, and these marks have been laid down on all the planetable sections taken up since. The assistance thus granted...he states to be of the greatest importance [285, 290][2].

During season 1854-5, the party observed no fewer than 1,200 triangles and surveyed 1,919 square miles by planetable ; sheet No. 2 was completed, fair-drawn, and sent to India House as a sample of the work [214].

Being exceedingly fortunate in the weather, Mr. Hörst and myself completed the triangulation by the 26th of March when we marched east to take observations for height in the neighbourhood of Jhelum...and in...the country already planetabled, not only for the high points, but also for the low obligatory points [67–9].

I also corrected my former survey of the Great Trunk Road between Jhilam and Rawal Pindi which was very erroneous. When the former survey was made the line was only traced out, and since that time very considerable alterations have been made, ... and the road has been nearly finished. ... This survey afforded a splendid opportunity of testing the accuracy of the planetable work...and very satisfactory was the result.

Nothing could be more correct than the work of the two James, but Mr. Chamarett's was not so good. His ridges are generally correct, but his watercourses have been put in carelessly. ... Mr. Chamarett is an excellent topographical draughtsman, his work is neat, clean, and well got up, and if he would but take more pains to produce *really* accurate, rather than *approximately* accurate work, I should be very pleased with him[3].

Season 1855-6, triangulation was extended into the desert country south of the Salt Range, and towards Kālābāgh on the Indus. The season was remarkably unfavourable. No rain fell...for four months, and although in the latter end of March and all April we had daily severe dust storms, no rain accompanied them, so that the atmosphere was intense. Even in the latter end of February the thermometer daily stood at 100° in my double-poled tent, and that combined with the bad water of the desert induced a good deal of sickness, principally brain-fever and dysentery.

Our progress...has not been good. I had hoped to have completed the triangulation this year, but I have still three stations left unobserved. ... These could not be built in time for me to visit them owing to the difficulty of procuring lime, water, and labour, ... and even if I had the stations built the weather at the end of April was utterly unfit for observations. ...

When I observed from these stations in the past season it was with great difficulty I saw the heliotropes, and opaque objects were, of course, quite invisible. ... The mirage arising from the salt desert which skirts the southern face of the Salt Range far exceeds anything I have ever seen before. Morning observations could not be taken, neither could I get reciprocal verticals at minimum refraction between the stations in the plains [63–5].

[1] DDn. 712 (232), Robinson to Comnr., 2-3-55. [2] DDn. 731 (10), 24-12-58 ; DDn. 714 (129), Report for, 1856–7. [3] DDn. 593 (499), Report, 1854–5.

Less planetabling has been done. ... Total area...1,197 square miles. This is an unusually small area for so large an expenditure, but...a very much larger amount of mapping than usual has been brought up[1].

Work was carried on right through season 1857–8 in spite of trouble elsewhere ;

Owing to the disturbances around Murree and the probability of the rebellion spreading over a large portion of Hazara [482, 485], we were unable to take the field before the 23rd of October. ... Much trouble was experienced in getting carriage for the instruments. No coolies could be procured, and the civil authorities were forbidden to press them. None of the khalasies had returned from furlough...so that if it had not been for the assistance...by the revenue surveys we should have been delayed several days. ... At Rawalpindi we were detained several days. ... It was not until the 1st of November that...we marched. ... Being thus short-handed we were obliged to confine ourselves almost entirely to planetable surveying.

Robinson himself planetabled about 60 miles of "very difficult ground" and the party outturn amounted to 1,484 square miles ;

I regret that my own health prevented my doing more work. I was taken ill on the 15th March, and from that date have been too weak to stand exposure, though never unable to direct. ... My illness arose from over-exertion and exposure...in a most changeable climate.

The party all returned into quarters between 15th April and 5th May, after which Messrs. Ryall and Todd started to join the Kashmir party[2] [231].

The country south of the Salt Range was now under survey by the Sind-Sāgar revenue survey party and, writes Waugh to Robinson,

on account of a change in the district boundaries which are no longer conterminous with the limits of the hill tract, the space you were authorized to survey does not now conform to district limits. Lieutenant F. Anderson's operations, being essentially for revenue survey purposes, ought...to include complete districts, otherwise it will not fulfil its special object. ...

In the event of your surveys overlapping, it will be indispensable to settle any difference... on the spot. As Lieutenant Anderson will have free use of all the trigonometrical stations the means of effecting an harmonious union will be ample. ... As regards your own limits, ... let the base of the hills be the limiting line, leaving all cultivation in the plains for the Revenue Surveyors. ... I...wish that all your field operations should be completed satisfactorily by the close of the next field season [1858–9], without any blanks, defects, or omissions[3] [275–6].

For the start of the final season 1858–9

Messrs. Hörst, Bell, and Ryall marched out [from Murree] on 1st of October, and Messrs. Todd and Neale, ... did not rejoin from the Kashmir party until later. ...

[In] the vicinity of Mt. Sakesar[4] [4994 ft.] I took up with Mr. Baness the planetable which ...I was obliged to leave unfinished in 1857–58. I remained instructing him nearly three weeks and then continued the measurement of obligatory points until Lieut. Murray joined me on 2nd January[5]. ... It was necessary to give Lieutenant Murray, a practised topographical surveyor, a little instruction owing to our style and scale being different. ... The rest of the season I spent in measuring obligatory points [68] and...I inspected the different planetables. ...

On the 8th of March I...commenced my march to Lahore. ... The first party joined at your headquarters at Dehra Doon on 2nd April, and the remainder on the 21st April. ...

During the past season I introduced the practice of each surveyor furnishing with his monthly progress report a small sketch showing the amount of work completed during the month, and expected to be done during the ensuing month. These sketches were very useful[6]. ... They assisted me very much in looking for obligatory points. ...

I have great pleasure in reporting very favourably of the whole party. The...surveyors have improved very much in drawing, and some of the tables executed during this...season are first-rate specimens of topographical drawing. Our field work is now all completed, the computations are very nearly all brought up, and I hope when the ground maps are completed ...they will meet with your approval[7].

The fair maps were now completed on the one-inch and ½-inch scales at Dehra Dūn, under the anxious eye of the Surveyor General ;

I am at present engaged with Captain Robinson in bringing up the survey of Jhelum and Rawalpindee, a most intricate tract exhibiting peculiar geological characters, the delineation of which on a large scale has been most faithfully and beautifully rendered. ...

The details...have been carried out in strict accordance with the system developed in my printed topographical instructions [211]. ... There remains a great mass of computations to

[1] DDn. 714 (54), Report, 1855–6. [2] ib. (118, 137), 11–6 & 20–12–58. [3] DDn. 687 (9), 1–7–58.
[4] 25 m. E. of Miānwāli. [5] from Kashmir. [6] still in practice, 1920. [7] DDn. 714 (156), Report, 1858–9.

bring up...and several maps to draw before the survey can be considered finished. These duties...will furnish at least twelve months of hard industrious work. ...

Captain Robinson is the only person who has been with this survey since it's commencement, and...no one can complete what remains to be done so efficiently as himself. It is a standing rule...that the responsible parties shall bring the work up. ... The general map has been necessarily postponed because if commenced sooner the paper would have become spoiled. ... A previous attempt made by Captain Robinson proved abortive, and the general compilation has been recommenced de novo under my supervision. ...

The large-scale maps are in a great state of forwardness and one sheet was transmitted home in 1855 as a specimen [212]. ... If completed in the same uniform style...these maps will stand in the first rank of topographical achievements in India[1] [318].

All was complete by October 1860, when the party took up work in a new area, Gwalior and Central India [190], and Robinson submitted

angle-books, computations, maps, charts, and general report of the survey of the kohistan[2] of the Sind-Saugor Doab, commenced by me in November 1851, and brought to a close in March 1859, the past year being spent in the preparation of...maps and reports.

The original angle-books...have been several times examined and the duplicates...carefully compared. ... A list of villages has been compiled alphabetically from the village books. ...

An index sketch...[shows] the numbering of the planetable sheets. ... Some of the planetables...have been recopied so as to maintain the same character throughout, ... and to afford the means of compiling a duplicate of the general map...should the original be lost. ... It is very satisfactory to observe how well the planetable sheets agree, not only in accuracy of delineation, but also in style and depth of colour after 3 or 4 years practice. ...

The general maps...are compiled from the planetable sheets. They are arranged in sections of one degree long by half a degree wide, excepting No. 8, ... made somewhat wider. ... The reduced map on the quarter-inch scale for incorporation with the Indian Atlas has been made as complete as the scale admits of[3].

The topographical survey of the kohistan Sind-Saugor doab...is...the work of nearly eight...field seasons. The tract...embraces the...districts of Rawalpindi and Jhelum, and the hilly parts of...Shahpore and Leia, ... an area of 10,554 square miles...bounded by the rivers Jhilum and Indus, the lofty mountains of Hazara, and the plains at the base of the Salt Range.

Taking into consideration that much of this tract contains as numerous a population...as many good plains tracts, its unfitness for the operations of a revenue survey, and the necessity for good maps for military and engineering purposes, the Surveyor General ordered the...scale of one inch to one mile—that the heights of all obligatory and important points should be carefully laid down by trigonometrical levelling—that all areas of cultivation and waste, and size of villages, should be shown. ... These instructions have been carefully carried out, and latterly the trijunction pillars...have been laid down at the request of the settlement officers, whereby they...are as well off as if they had had a regular revenue survey [211–2, 290]. ...

The cost of this great work has been Co.'s Rs. 18-5-2 per square mile to the end of 1859[4]. The eight sheets on the one-inch scale and the reduction on the ¼-inch scale were lithographed in England [317][5].

Robinson had indeed made an outstanding contribution to the surveys of India by the high standard of his planetable survey and mapping [289–90].

PESHĀWAR, 1849–53

After the close of the 2nd Sikh war which had ended with the battle of Gujrāt, 21st February 1849, James Walker and Arthur Garnett were deputed to make a "military survey" of Peshāwar and its surroundings within a 10-mile radius[6]. Between April and June, having measured a base-line of 2½ miles and observed some rough triangles with a 3½-inch theodolite, they surveyed about 400 square miles on the 2-inch scale, west of the road that runs from Shabkadr Fort through Peshāwar to the Kohāt Pass. Whilst Walker was making fair copies Garnett was

[1] DDn. 643 (301) & 668 (88), to SG. Mil. Dept., 7–6- & 23–9–59. [2] hill country. [3] *IO Cat.* (251); 1-inch map, MRIO. Misc., 32–0–59 ; & 7 (37) 8 sections [pl. 12]; 1″ boundary traces, ¼-inch map ; MRIO. 7 (38) : Misc., 30–0–59. [4] DDn. 714 (198–203), Completion Report, 3–10–60, also *IO Cat.* (24) ; SG.'s final report, also DDn. 21 (30–3), 29–1–61. [5] *IO Cat.* (251–3). [6] *GTS.* III & *Syn.* 1 (XI–XIV—D) ; DDn. 549 (63), 19–9–53 & 593 (187), Walker to SG., 21–5–51.

DISTRICTS OF JHELUM & RĀWALPINDI

Surveyed on one-inch scale under Lieutenant Robinson, Bengal Engineers, seasons 1851 to 1854 [ch. xiv].

Part of Sheet 2 of eight sheets, each of one degree in longitude and half a degree in latitude. This fair copy, drawn in the Surveyor General's Office at Calcutta, was completed 10th Feb. 1857; MRIO. 7 (37).

Robinson's triangulation was based on the North-West Himālayan Series, G.T.S., the heights of which were brought up from sea-level at Calcutta through the North-East Longitudinal Series.

This portion of the Grand Trunk Road was constructed between 1847 and 1852.

Mangla Fort lies about 15 m. north of Jhelum city.

See also plate 9 for Robinson's survey of Attock District, then part of Rāwalpindi, and Walker's survey beyond the Indus [209–17].

John. A. Smith

D. J. Robinson, Lieut. Engineers
& A. Deputy


Plate 12
See notes overleaf
Badiark
Kuri
Pothia
Rondala pole
Rondala
Rathli of Phangali
Rathli
Lori
Pole Lori Hill
Bhukara mora
Pharagali
Naka of Phangali
Dhat
Hail
Pole Gorsia Hill
Kirnari
Chamarala
Mora
Kalaca
Kookal
Pandora
Sai ka Thok
Sai ki dhok
Thane
Bodkhem
Bakla
Manara
Ladhar
Sab chak
Mangola
Sagri
Doome
Nakodar
Jala chak
Sid
Pindi
Chani
Kuri
Padra
Chakla
Pimpra
Pole Pind Jalab ki
Pachar
Madlo Kalas
Jagir Naki
Jatapura
Wakl pole
Adala
Adali
Thikriya
Rabdal
Sukanpur
Thil
Mangla
Khari
Changur
Bar
Highest flood 1886

transferred to Kohāt where he made further useful surveys [217][1]. In September Walker resumed survey with the assistance of Allom of the Bombay Artillery, who died a month later.

On the return of the Bombay Division to its own Presidency in January 1850, Walker was retained on the survey under the Board of Administration at Lahore [36, 273][2]. During December he accompanied a military force to Yusufzai as engineer, and extended his survey northwards to the Kābul River. He measured another short base and surveyed about 150 square miles, still on the 2-inch scale, returning to cantonments in May.

In those days his escort merely consisted of a couple of sowars, one of whom usually carried a small theodolite and the other a folding tripod-stand. All he could do was to go on until shot at and then return, and this he did on several occasions until advised by...the Commissioner of Peshawar that it was not desirable. A dotted line on his original map shows the line beyond which 'further proceedings were stopped by the hostility of the natives'[3].

In September 1850 two native surveyors were sanctioned, but as trained men were not procurable, four moonshees were successively entertained on trial. Of these one eventually answered, by name Mirza Sajjad, a native of Persia [47], who remained on the survey throughout the last two field seasons, and rendered valuable assistance by traversing the banks of rivers and ravines which could not otherwise have been laid down with so much detail. But he was incapable of field sketching or computing[4].

In November 1850, Walker resumed survey in the Yusufzai area, working eastward to the Indus, down to Attock, and then closing on his earlier triangulation near Nowshera. He filled in detail between his triangles by compass bearings which were plotted later[5]. On various occasions he extended his surveys by accompanying military columns, and sometimes won the assistance of local tribesmen to reach a point of vantage whence he could sketch otherwise inaccessible ground.

In April 1851, he was placed under the orders of the Surveyor General and made his first professional report, and in September sent a copy of his map to Calcutta to be lithographed in three sheets. He apologised for not having been able to observe the latitude of Peshāwar ; his heights were only roughly approximate [217], and the only azimuth was derived from "a small prismatic compass" [II, 232][6].

By the end of 1851 he had surveyed about 3,000 square miles, of the Peshāwar valley including the country of the Yusufzai to the north, most of which was controlled by rough triangulation. He had incorporated rough sketches made by local military officers[7], and sketched about 800 square miles of distant tribal territory. From October 1851, he extended survey south and east along the north Khattack range in Afridi country.

During January 1852, he visited the Surveyor General's camp near Peshāwar, and received a 7-inch theodolite and much good advice, and he then visited Logan's camp to discuss arrangements for the connection of Peshāwar and his own triangulation by Johnson and James [37, 86, 475]. He describes the somewhat amateurish methods of his earlier work ;

At the outset the compass alone was used, in the manner laid down in books on Military Surveying. 2ndly., the theodolite took the place of the compass, ... the observations...being noted in a fieldbook. ... 3rdly., the remainder...was sketched on a planetable [12-inch square]. ... The rays were taken—not, as usual, with a sight rule—but with a theodolite, and afterwards recorded in writing, because the rapidity of the survey and...its danger and difficulty necessitated occasional observations to objects so distant that some time would elapse before the final intersections could be completed.

The river Indus...and some of the larger ravines were traversed with a compass and perambulator by a native surveyor working on departure and terminal points fixed by myself. These traverses had to be carried over very broken, difficult, ground. ... Their error was rarely more than 2 or 3 per cent. They were plotted by the native surveyor on the scale of 2 inches = 1 mile, and then reduced on my own plans with a pentograph[8].

[1] *IO Cat.* (467), with Lumsden, 1855–6, Miranzai & Kurram. [2] on staff salary Rs. 350 pm. [3] *GTS.* III & *Syn.* I (xx—D). [4] DDn. 593 (543) & *Punjab. Sel.*, II (xii) ; Walker's Report, 11-9-54. [5] scale now 1-inch. [6] MRIO. 8 (22-3) ; original svy. without graticule ; hand printing by Gunner Hawthorne. [7] v. MRIO. Misc., 21-O-52 ; sketch by Guides officer on Swāt R. [8] Mirza Sajjad [*sup.*, 447–8] ; DDn. 593 (301), 28-O-52.

He spent the summer of 1852 in Murree [48], and in October submitted the fourth sheet of his survey covering the Khattak hills to the south, acknowledging the great improvement effected by use of the larger theodolite. He had now received the preliminary values of Logan's principal triangles, and of James' secondary connection [37; pl. 2]. From his own westerly stations north of Bahādur-Khel fort, he had fixed many prominent trans-frontier hills, including snow peaks of the Safed Koh [86]. He describes his precautions against Pathān tribesmen [474];

I never went to any point twice, excepting to those I intended for trigonometrical stations; these I had to visit, the first time to build a pillar and clear the rays, and the second to take the requisite observations. It is obvious this rule is incompatible with planetabling for which a point in every 4 miles had to be fixed from the primary stations, and therefore must...be twice visited. At every point I took such a number of observations for the filling in as would prevent the necessity of my ever having to return to it. These were observed with a small theodolite clamped at zero to a referring mark due north. ...

In reconnoitring for the triangulation...no sketching could be effected as the base work of the triangles was not ready. 'In this case all the observations were entered into a fieldbook ready to be used as soon as the triangles were plotted. Then, taking the plotted sheet to some other station, ... I drew the rays entered in the fieldbook, and with a theodolite clamped as above, I intersected them by observations plotted on the spot, afterwards performing similar operations from some other station.

By the end of field season 1852–3, he had completed survey of the whole of the British territories west of the Indus from Peshāwar down to the parallel of Dera Ismail Khān, 8,700 square miles, and had sketched about 11,000 miles beyond the tribal border. Except for the small area surveyed on the 2-inch scale immediately round Peshāwar and mapped on the one-inch, the work had been plotted on the one-inch scale, and reduced to half that scale at Calcutta before lithography[1]. The area south of Kohāt was, however, laid down on the half-inch scale in the first place. Walker claimed no great accuracy for his work;

The map must not be supposed to be perfect. The means available did not warrant an attempt to achieve that accurate delineation...which can only be obtained by...systematic operations, requiring large establishments and ample resources. ...

Operations have occupied only four and a half years...to the completion of the fair copy maps. ... All...that could be done after the villages and chief points had been determined...was to sketch minor features from the summit of commanding positions[2].

He wrote from Bannu on 1st April 1853 that by the 20th he hoped to

have completed...work in the Bannoo valley, and to commence my march to Mussoorie, a long way to go. ... The weather is beginning to be very hot and feverish; ... I have already had to resort to quinine; with its help...I hope to get through my work[3] [459].

He reached Mussoorie about 17th May, and reported that during 1852–3 he had completed the survey of the whole highland frontier trans-Indus, embracing the southern Khattacks and Bunnoo, besides extending a reconnaissance into the plains of Derajat as far as Dera Ishmail Khan. ... He carried a principal series along the Indus as far as Sheikh Boodin; ... two of his stations...fixed by the Great Trigonometrical Survey [47–9]. ...

Between his principal series and the Waziri boundary there is a large open plain called the Thull, over which he might have triangulated, but...with considerable difficulty for there is no water on this Thull nearer than the Kooram River, consequently it would have caused much delay and expense to build white masonry pillars, the only opaque objects that could be observed with certainty on these brown sandy plains [228, 232].

The use of heliotropes was interdicted by the nature of the country...because signals of that kind require detached parties. ... At that time we were not at peace with the Waziris. ...

After completing up to the Kooram he availed himself of a few remaining weeks of cold weather to connect a survey that had been made by Lieut. Miller and Dr. Lyall of the Guide Corps round Bunnoo[4]. ... Having effected this connection he made a general rough sketch of the remainder of the Bunnoo [area], and also of the frontier down to Dera Ishmail Khan[5].

No attempt was made to survey the valley of the Kyber on account of the opposition that would certainly have been met with. ... Of...the vicinity of Lundikhana a very beautiful

[1] MRIO. 9 (1), 114 (36–41); sheets adjusted to OTS. [2] *Punjab Sel.*, 1855; II; xii, Walker's Report, 1–9–54. [3] DDn. 545 (350). [4] H. N. Miller, 2nd in comd. Guides; MRIO. Misc., 21–0–52, sketch N. of Charsadda; Dr. Robt. Lyell (1825–57), MO. with Guides; kd., Patna 3–7–57. [5] DDn. 549 (63), SG. to Mil. Dept., 19–9–53 (256–62); 593 (377); Walker to SG., 18–6–53.

pencil drawing was executed by Lieut. Goodwyn of the Bengal Engineers[1], and is now in the drawing school at Roorki [IV, 471 ; V, 282]. The only sketch...of the whole pass...was a rough reconnaissance done by Major Leech of the Bombay Engineers on a small scale without much detail [IV, 278]. It is in the possession of the Quartermaster General of the Bengal Army, who kindly permitted its incorporation into this survey. ...

The Kohat Pass was surveyed with a perambulator and compass in February 1850, at the time of Sir Charles Napier's expedition. ... The valley of Dower [Tochi] was reconnoitred from the low hills west of Bunnoo, near the gorge through which the Tochee River passes. ... A great many villages were seen and their bearings observed. ...

Work was not extended south of Sheikhbudin as the country had now reached a dead level plain, very well suited to chain measurement, but very ill suited to rapid reconnaissance. Hitherto, though large plains had been surveyed, there were always hills at hand which gave good points for triangulation and extensive prospects for sketching[2].

The city and environs of Peshawar was reduced from a survey by Lieutenant Grindall of Engineers on a scale of 6 inches = 1 mile. ...

The heights on the map...were based on Dr. Griffith's determination of the height of Peshawar [IV, 447]. I never attempted a regular system of vertical observations in the early part of my operations because the spirit level of the vertical arc to my best instrument was broken. The map had left me long before I received either the G.T. Survey data for heights, or a decent instrument with which to observe vertical angles [215][3].

He was later able to submit further material ;

The valley of the Koorrum and all else to the south of the Soofeyd Koh range and west of the British boundary was originally laid down almost entirely from native information. This...has...been...replaced by...the survey under Lieuts. Garnett and Lumsden during Brigadier Chamberlain's expedition to the Koorrum in 1856 [215 n.1]. I have also added some information...from a reconnaissance by Lt. Lumsden...during the mission to Candahar in 1857 [pl. 2]. The hills and villages...near the northern entrance to the Kohat Pass...were forced by the expedition...in 1856. They were then surveyed by Lt. Lumsden, and the information ...has been incorporated into the map[4].

Country of the Mahsood Wuzeeries :—surveyed by officers attached to the Great Indus series during the expedition in April and May last [1860] under Brigadier General Chamberlain. The survey is based on 5 secondary hill stations fixed by Lt. Basevi and myself, and on a traverse...by Lt. Basevi assisted by Lt. Branfill. ... The road was exceedingly tortuous and generally very narrow, and the surveyors were compelled to remain with the Army, ... much impeded by the troops and baggage. The hill sketching was done from stations...fixed by interpolation ; ... angles...measured with a 7-inch theodolite. Verticals were occasionally taken...from the known heights of Pirghul or Shewy Dur [IV, 33 ; V, 219][5].

DERAJĀT, 1855–60

In 1850 it had been proposed that Robinson's survey should swing across the Indus near Kālābāgh to cover the country lying on the right bank as far south as Mithankot as an extension of Walker's survey. This would cover the Derajāt, the stretch of plain between the river and the tribal hills, including the districts of Dera Ismail Khān, Dera Fateh Khān, and Dera Ghāzi Khān, that had come under British control from 1849. This proposal having to be postponed for political reasons [209–11], it was suggested in 1855 that a topographical survey should be extended down the Derajat and through the Dera Ghazee Khan district to the confines of Sindh. This effected, nothing more in the way of surveying will be needed for the frontier. Political and economical considerations arising from the condition of the people and the nature of the country seem to preclude...a revenue survey. ... The continuation of the topographical survey might...be well performed by one of the...assistants in the Punjab revenue surveys... with a limited party[6]. ...

The topographical survey by Lieutenant Walker...down to the parallel of Dera Ismail Khan has been conducted under the Surveyor General's special superintendence. The

[1] Henry Goodwyn, junr. (1831–50) 2/Lt. Ben. Engrs., 1851. [2] DDn. 593 (543), Walker's report, 11-9-54. [3] DDn. 710 (228), Walker to SG., 29-9-56, covering 1-inch map in 3 sheets ; *IO Cat.* (237–8), 1-inch and ½-inch maps with memoir ; MSS. [4] DDn. 674 (145), 8-10-58. [5] DDn. 710 (319), 16-8-60 ; & (308), 5-6-60 ; DDn. 5 (1), acks., coloured litho. prints of this svy., *IO Cat.* (467). [6] DDn. 661 (58), Ch. Comnr. to PD., 15-5-55.

continuation, therefore, of a similar...survey, viz., minor triangulation and planetable sketching, ... to be referred for the opinion of that officer[1].

It was decided to depute Henry Johnstone from Shortrede's party [274]; Ultimately the cost of the work is not to be more than 7 rupees a square mile, on the average. It is hoped that the annual expenditure being less than half that of a revenue survey, ... may be deemed moderate. The map should be...on a scale of two inches to a mile. ... These objects are partly civil, fiscal, and general, and partly military and political.

The undulations of the ground, the course of the streams and ravines, the physical peculiarities, ... should all be noted. ... Village sites—the cultivation dependent on the hill torrents—... dry cultivation occupying the centre of the tract—Indus canals and water cuts—... waste, whether bare or overgrown with jungle—roads—frontier posts—should be distinguished.

It may be proper to note the boundaries of districts and even of internal police and fiscal jurisdictions, and...your map will...furnish the readiest means for the final adjustment of those boundaries. ... The boundaries of estates need not be denoted[2].

Johnstone commenced survey "at the lower extremity of the frontier near Mittunkot" in December 1855, with a small party of two sub-assistants and 12 Indian surveyors, and in March 1856 was placed directly under the orders of the Deputy Surveyor General, the party being strengthened by another sub-assistant and six Indian surveyors[3]. The tract lies, writes Thuillier,

between the Indus and the frontier military road from the Sindh boundary up to a few miles north of Mithunkote. ... The tract of plains lying between the river and the frontier road will all be done according to the usual revenue survey circuit system, whilst all to the west of the road will be executed on a trigonometrical basis, the topography...of both descriptions of country being filled in by the planetable. The main circuits have been subdivided in the usual way by traverse and theodolite into convenient sized blocks, and these again by planetable for closing and starting points, on which the interior details were laid down.

The entire area may be said to be jungle, relieved by the smallest proportion of cultivated land and villages. The season's work has been rendered on the one-inch scale, and the field sections on the two-inch scale. ...

The work west of the frontier road, and up to the passes, will be far more difficult. This is now in progress, requiring great personal activity and judgement on the part of the surveyors to guard against the wild and lawless tribes inhabiting the hills forming the spurs of the Sulaimaun Range, and who incessantly make forays down into the British territory. Indeed the whole work has to be done under the protection of a revolver, and every person connected with the survey is well armed. The survey parties are obliged to return daily under cover of the military frontier posts[4].

In 1859 Johnstone submitted a contingent bill to cover

sums paid...to various hill tribes. ... These tribes are independent, and the only tolerably safe way of surveying their hills was to pay for permission. I had a military guard—this was really necessary—but no amount of guard that could be spared me would be sufficient to force an entry into the country of tribes who number thousands of fighting men. ... I effected the survey of the hills these last two years at the imminent risk of my life. ...

I lately reported that work for one more season only remains in the Derajat. This will carry the survey as far north as Peyzoo or the base of the hills which separate the Derajat from Bannoo. ... [Is it] the desire of...Government to have the survey carried further north? ... The districts to the north are Bunnoo and Kohat. ... Kohat would have to be done by European agency alone. To make a map...of these two districts as elaborate and complete as I have made of the Derajat would be very expensive[5].

The Surveyor General thought the survey should overlap Walker's;

The southern portion of Major Walker's trans-Indus maps was...never intended to serve more than a temporary purpose. ... Advantage should be taken...to extend Captain Johnstone's operations over the plains of Banno and Marwat. The same reason does not apply to the case of Peshawar, and as a general rule re-surveys are objectionable. ... The original survey was for military purposes...when the country was unsettled. ... Great changes have since taken place, and...I am not prepared to offer the usual objections to this revision[6].

It was eventually decided that Johnstone should not extend his survey into Kohāt, but should re-survey Bannu, and this was effected during season 1860-1.

[1] DDn. 661 DSG. to FD., 4-6-55. [2] DDn. 662 (98, 158), Ch. Comnr. to FD. & Shortrede; 15-11-55, 9-5-56. [3] DDn. 662 (98), DSG. to FD., 11-3-56. [4] DDn. 624 (161-3), DSG. to SG., 1-2-57. [5] DDn. 668 (58—A), Johnstone to Punjab Govt., 24-2-59. [6] DDn. 666 (71), SG. to DSG., 3-8-59.

During his two previous seasons he had carried survey along the border hills "without any direct collision with the people" ;

I found large, powerful, and lawless clans—the Bozdars alone mustered upwards of 3,000 fighting men—who had scarcely ever seen an European except at the head of troops sent for their chastisement, and were consequently extremely jealous of my entry into their country.

By paying the chiefs, and rewarding guides and villagers, I got sulky admittance into the mountains. On several occasions the clans assembled in force and were with difficulty quieted. Having no military assistant, ... all the hills had to be surveyed by me alone.

The most dangerous part was the line from the Goomul valley northwards. ... Our survey parties were fortunate enough to escape molestation. My own presence moving up and down close under the hills with a strong guard was some...protection. ...

I was unable [1859–60] to go about among the hills as I had done during former years. ... Strict orders were issued that no European was to cross the frontier line, the base of the first range of hills. ... I was obliged to content myself, therefore, with ascending peaks in near ranges. The country, in consequence, near the Soleiman mountains is not so correctly laid down as in past years. Sketching from distant points, aided...by numerous intersections, was the method pursued.

In November 1859, Captain Mecham of the Bengal Artillery was murdered near Bunnoo by a party of Wuzeerees. ... A military expedition was organized...and I was ordered to accompany. I mapped the country we went through, but to make the survey complete a few points were wanted which I could not get at last season, which I shall visit during the ensuing winter. ...

In March 1860, the Mahsud Wazeerees...made an attack. ... An expedition...marched from Tonk on the 15th April. The Mahsood Wuzeeree country, hitherto unknown, was now completely explored. The survey was done by Major Walker [49, 217]. ... I got back to recess quarters at the end of May, ... riding up the frontier from Bunnoo, mail-carting from Peshawar to Rawal Pindee, and riding up the hill to Murree. Thus nearly four months of my time was taken up with duties other than my regular work[1].

Among other incidents was a punitive expedition which Johnstone accompanied into the hills where the civil authorities burnt "the Lisharee settlements on Buhishto".

He then proceeded with an escort of 100 infantry and 40 cavalry up the Chachur Pass to look at the Shum plain[2], and ascending Maree from its western side. The trip was considered as attended with a good deal of danger. ...

After completing survey work which took a couple of days, ... our road was down a very difficult gorge on the east side of the mountain. ... Fired on from the cliffs above, and one man of the party killed. ... During the four years I was engaged in surveying the hills to the west of the Dera Ghazi Khan district, though several times fired on and placed in positions of considerable danger and difficulty, this was the only casualty I ever had. ...

When I went through the Bozdar hills in January 1859, two of their chiefs accompanied me, but a third...used all his influence to get the clan to attack my camp. I had a guard of 130 bayonets and 30 sabres, and would have had probably but little chance, ... but—undecided how to act—they lost their chance. Before they had made up their minds I had surveyed and left their country, but only just in time[3].

A reduced quarter-inch map was published in two sections. The southern showing the Dera Ghāzi Khān district from the Kashmor post on the Jacobābād frontier extended 294 miles to Dera Fateh Khān and covered 10.271 square miles. The northern covered Dera Ismail Khān and Bannu districts[4]. The southern section, completed in 1861 was "lithographed in superior style. By the system of double printing the hills, which are of a very intricate character, have been drawn in chalk, by which a very good and soft effect is obtained. The map measures 5 feet by 3" [331].

At the close of season 1860–1, Johnstone and his party were transferred to regular revenue surveys in the Delhi area, but returned to the north-west frontier two years later and remained there till his retirement in 1878[5].

[1] *GR Rev., 1858–61* (117–8). [2] MRIO. 4 (18), Punjab sheet 3 [317 D.1]; SHUM plain, about 29° 15′ N.; 69° 45′ E., "belonging to Shumbanee Bhugtee tribe; the *druggatie*, or wild ass...enjoy sole and quiet possession...and revel in its luxuriant crops of grass". [3] Johnstone (7–10); cf. *GR Rev. 1858–61* (108). [4] ½-inch map, NWF., MRIO. 114 (30); *IO Cat.* (242–3), with D.I.K. & D.G.K., City & Cants., 8 inches to 1 m. [5] *GR Rev., 1858–61* (116).

CHAPTER XV

KASHMIR, 1855–65[1]

Preparation, 1849–55 — Pir Panjāl, 1855 — Kashmir Valley, 1856 — Kashmir & Jammu, 1857–8 — Baltistan & Ladākh, 1858–61 — Trans-Himālaya, 1862–5 — Maps & Memoirs — Little Tibet.

KASHMIR had long been a land of romance. The beauty of its scenery, its valley of lakes and winding rivers set in a circle of snow-clad mountains, the skill of its craftsmen, its remoteness, and the rigours and hazards of the journey from the outside world, all added to its fascination. Its position on the maps of the world, its delightful climate, and its setting amid the mountains, attracted explorers of all nationalities and callings, and many and varied were the descriptive journals, serious memoirs, and lucid sketch maps that added to the store of knowledge and speculation—Desideri [I : 68–9 ; V, 240]—Izzut Ullah [III, 485–6]—Moorcroft & Trebeck [III, 44, 485–6 , 508 ; V, 187]—Vigne [III, 292 ; IV, 472]—Cunningham [IV, 269 ; V, 186–7]—and many others [III, 276 ; IV, 290–2 ; V, 240][2]. Precise geographical fact had to await the passing of Sikh rule and the coming of the Great Trigonometrical Survey.

The nineteenth-century story of Kashmir opens with the decline of muslim influence from Peshāwar that was finally broken by the Sikhs between 1819 and 1821 [III, 43 n.2]. In 1820, a Dogra prince, Gulāb Singh[3] was created Rāja of Jammu as reward for military services to Ranjīt Singh. A man of energy and ambition, he had by 1842, extended his dominions over Rājaori, Kishtwār, Ladākh, and Skārdo[4], and had closely encircled the Kashmir valley. In 1846, at the close of the first Sikh war he undertook payment to the British of Rs. 75 lacs, part of the indemnity, that had been imposed on the Lahore durbar, in return for recognition by both Sikhs and British as sovereign Mahārāja of Jammu and Kashmir, with all hill tracts between the Rāvi and Indus rivers[5].

At the end of 1849, the British authorities obtained permission from the Mahārāja for the principal triangles of the North-West Himālaya series to pass through Jammu territory, but owing to local objection to the occupation of a sacred hill-top, Trikota, the line of triangles to the Indus was shifted to the southern fringes of the Mahārāja's territories [35–7, 472].

In 1853, when the topographical survey of the north-west Himālaya was drawing to a close, the Surveyor General approached Government with proposals for the full triangulation and detailed topographical survey of Jammu and Kashmir, to which the Mahārāja readily assented [3, 5].

> The course of the principal series extending from Dehra Doon base to Peshawar passes through the southern border of Maharaja Goolab Sing's territories, and...His Highness offered every facility and support. ... The Maharajah's territories have not been surveyed in detail, the operations...consisting merely of the skeleton series. ...
>
> The whole mountain tract lying east of the Maharajah's territories extending across the snowy range to the northern limit of our territories has been surveyed in detail [200–8]. ... On the west side of the Maharajah's kingdom the whole mountain region has been either completely surveyed up to the Peshawar frontier, or is now under survey [4–5, 208–17]. ... Thus the only portion of mountains under British influence which has not been regularly surveyed is His Highness the Maharajah's territories, including Cashmeer.

[1] full narrative, *GTS. Syn.* VII (xiii–1 : C). [2] cf. Stein. [3] (1792–1857). [4] Francke (137–60); Punch being held by a bro. [5] Treaty of Amritsar, 16–3–46; *Imp. Gaz., K. & J.* (26–8); Punjab, I (32); Aitchison, VIII (160–4); Pannikkar; *Statesman*, 10–1–1954 (Reviews); Lang (91 n.3); *IO Cal.* (232).

The plan of operations I drew up in 1847 contemplated the connection of Cashmeer by means of a series of triangles, and as the North-West Himalaya...party has now almost completed the work assigned to it, the means will be available for entering on the survey...in October next. ... The party which has hitherto been employed in the mountain survey has been trained with great pains to this...difficult kind of work, and has obtained that...experience which tends vastly to expedite work and reduce its expense. ... This experience and training will, however, be lost if the labours...are diverted to a different style of country[1].

Logan's principal triangles had been closed by the base-line measurement near Attock early in 1854 [37] and the Himālaya topographical survey being completed eastward to the Ganges during the course of the year [206–8], the Surveyor General informed the Chief Commissioner at Lahore that

the party designated for triangulating the territories of His Highness the Maharaja Goolab Singh preparatory to a general topographical survey will be ready to enter upon this enterprise immediately after the measurement of the Karachi base-line...about March next. ...

As the...survey will require large triangulation, with stations on the snowy mountains, the climate would not be favourable till the spring of the year, and as Lieutenant Montgomerie whom I propose to place at the head of the party will be required at the base measurement, the arrangement I propose will suit both purposes. ...

The triangulation of so difficult a tract...will be an arduous undertaking, and until it has advanced considerably it would not be advisable to take up the topography. By the time the basis is laid out I expect Lieutenant Robinson's party will have brought the survey of Rawalpindi and Jhelum nearly to a termination, and...will be available to take up the topography of the Maharaja's territories[2].

Formal sanction was obtained, and a departmental order issued ;

The party hitherto designated the North-West Himalaya series is transferred for this duty and will be denominated the Kashmir Series from the 1st January [1855]. Lieutenant Montgomerie...is nominated to the charge...and will make all the necessary arrangements. ... Consequent on Lt. Montgomerie's absence on duty at the base-line Mr. Mulheran will transfer the establishment and equipment to Mr. Johnson[3].

In his professional instructions the Surveyor General directed Montgomerie to carry his main series from a side of the North-West Himālaya longitudinal series, and to follow meridian 75° with a symmetrical double series that might form a continuation of the Bombay series through Ajmer [50–1 ; pls. 3, 6].

Take up any side of the N.W. Himalaya Series which may most facilitate the choice of your own stations, and combine with them in the simplest and most symmetrical manner. ... Your series should emanate from a single side, and not combine with any established figures. ...

Polygons are generally preferable on considerations of symmetry but, as the snow peaks will occasion formidable difficulties, it is not desirable to multiply them. ... Perhaps you may find a quadrilateral arrangement more convenient.

Your senior civil assistant, Mr. Johnson, ... has visited stations on the snowy range higher ...than the Panjal peaks. In fact, he has the distinguished merit of having observed with theodolite at a greater elevation than any human being has attained to [208]. ... The real difficulty will be to convey a large instrument safely to such heights, to occupy them long enough for the numerous observations, ... and to maintain signal parties thereon.

It will be desirable to use the 24-inch theodolite as far as...practicable, but...the 14-inch may be resorted to without apprehension.

He pointed out the difficulty of maintaining detached signal parties and

the interruption to heliotropes which clouds may occasion at the time of minimum refraction. ... It will be necessary to erect...permanent signals to mark your great stations on the snow peaks in order that they may hereafter be of use for the topographical survey.

He warned Montgomerie against relying on a single pair of intersecting rays when fixing unmarked points [17, 82, 91, 95, 234 n.5], and called attention to the precautions laid down for guarding against the vagaries of refraction [63–5]. He directed special attention to the heights of the higher peaks [87], and concluded ;

It will...be your duty to establish such relations with the local authorities of the Maharajah ...as may induce him to view your operations with satisfaction. ... The responsibility will also devolve on you...to leave a favourable impression on the people of the country, and repress all attempts at oppression on the part of your establishment[4] [236].

[1] DDn. 546 (20), from SG., 4–5–53 ; (237), from Govt., 27–7–53. [2] DDn. 547 (266), 12–9–54.
[3] DDn. 455 (223), do., 6–12–54. [4] DDn. 715 (37), 11–1–55.

PIR PANJĀL, 1855

Montgomerie met the party at Amritsar on the 23rd February 1855 [208] and having prepared the planetables, left Umritsar on the 2nd of March, ... crossing over the Ravee near Madhupoor [15 m. w. of Pathānkot], entered the territories of H.H. Maharajah Golab Singh, and skirted along the foot of the hills towards Gurhugarh H.S. [pl. 6].

At Purmundul I deposited the 24-inch and all other heavy baggage, including the sepoy guard. I then marched to Samnabanj, detaching Mr. Johnson to visit Ban H.S.; and...to the top of the peak called Siraoli[1] where it was detained two days, partly by fall of 6 inches of snow [37] and partly for...building the platform, removing black pines, etc.

From Siraoli the party proceeded...into the valley of the Toi [Tawi R.], up which it marched ...and then ascended to the top of this...remarkable triple-headed mountain[2], and the camp is now pitched on the centre peak over a bed of snow from 5 to 8 feet deep (snow now falling), but as the establishment has been gradually inured to the snow they are...generally cheerful. ...

With reference to the reconnaissance, nearly a square degree has been completed, taking in the greater part of the country between the Pir Panjal on the north, the plains on the south, between the Chatterdhar Range and the Ravee on the east, and the Rattan Pir and the Chenab on the west [pl. 6]. ...

Over the Banihal Pass...I have seen the great snowy range on the other side of Kashmir and...have laid down approximately...all the remarkable peaks. Thus having the general outline of the range, ... I have decided upon returning with Mr. Douglas for the final work, detaching Mr. Johnson to carry on the approximate series. ...

From what I have seen of the country...I have...decided upon using the 14-inch theodolite from the very commencement [157]. The transport of the 24-inch is quite practicable for the first quadrilateral, but the delay and expense would be very great, and so would probably be the opposition of the Maharajah, as he is decidedly averse to the making or even the repairing of roads. ... I still intend to use luminous signals as far as possible, and I hope to be able to use them on the Pir Panjal. Opaque signals have not been forgotten. I intend to erect one at Siraoli, ... a flat-topped hill. ...

The snow still continues to fall, but I hope to get away tomorrow[3].

He later reports that he had

fixed upon the side Gurhagarh H.S., to Samnabanj for the initial base. ... Siraoli and Karchunt, two peaks on the tail of the Chatterdhar Range forming the most symmetrical figure, ...were occupied accordingly. Though we had snow to contend with on both, ... wood being abundant, the masony pillars and platforms were built without much difficulty. ...

The second peak...was Karchunt, ... much higher than its rival Treckutta, and in the eyes of the natives nearly as sacred, if not more so. Its temple is in a flourishing condition, tended by Brahmins and supported by rich jagheers in the Towee valley. The spurs of this mountain are covered with shrines, the number of iron tridents of all shapes and sizes in them shew the veneration in which the natives hold this mountain [35–6]. ...

It was necessary to take possession of it quietly and without hurting their feelings. Our object was...carried out without in any way violating their prejudices, though I was forced to cut down a few of the oaks on the summit[4].

From Kārchunt he returned to take up final observations, leaving Johnson to continue the lay-out, with Muli peak[5] a formidable proposition;

It was absolutely necessary...to reside on the peak itself for several days (...on the snow, upwards of 15,000 feet above the sea). Grass, wood, and provisions had to be sent on ahead, and sufficient artificers and labourers had to accompany the party in order to clear away the snow, ... to build the platform and masonry pillar, construct a hut for the lamp party, etc.

The natives of the country were also much opposed to the ascent, their superstition leading them to consider the peak the abode of the Pir himself. This obstacle was overcome at last by...a good deal of persuasion; thus the party were enabled to reach the summit without undergoing anything beyond...a severe up-hill march over the snow, ascending no less than 7,000 and odd feet on the last day. ...

Mr. Johnson, ... in choosing a site for the station, of course took the highest part of the snow. This, however, did not coincide with the highest part of the mountain, and after removing a great quantity of snow no symptoms of the rock or ground could be perceived;

[1] 5 m. from the sacred hill Trikota [35]. [2] Kārchunt HS. [3] DDn. 609 (227), 11–4–55. [4] DDn. 609 (277–303); 692 (11); 716 (50), 20–3–56; cf. summary, *GTS. Syn.*, VII (xiii–xv—c). [5] Mulli HS. cf *GTS. Syn.* VII (xv—c); named after *dafadar* signalman [224]; peak Munt Mal, 14,936 ft. of 43 O.

another part was then tried, and there, fortunately, the rock was found within 11 feet of the surface of the snow. Soon after, ... the working party were surrounded with a thin cloud so charged with electricity that the hair and clothing of everybody crackled in the most unpleasant manner, and some of them emitted sparks. The work was consequently closed for that day.

The...electricity—added to the snow blindness, headaches, and cold that most of the natives were suffering from, in spite of their ingenious eye preservers made of pieces of fir twigs, horsehair, etc...—rendered it a matter of difficulty to prevent them from taking advantage of the snow to shoot down into a milder climate [207]. ...

All the water...for drinking and slaking the lime had to be procured by melting the snow. ... After some trouble a platform and...isolated pillar...for the instrument were finished, and a comfortable hut for the lamp party was constructed. Mr. Johnson...took all the necessary observations after the residence of several days on this peak, being much hindered by cloud and snow storms. Duffadar Moolee...was left in charge of this lamp party...of four men. ...

The approximate series was then carried into the valley of Kashmir. ... The party went down the valley, taking up stations on either side. ... Some of these...are high, but nothing remarkable was met with. The clouds and mist hindered the progress very much.

By the end of July Mr. Johnson reached the northern end of the valley, having thus carried the approximate series...over no less than 165 miles in 4½ months. The unfavourable weather and the necessity for change in the direction...prevented the further extension.

Montgomerie commenced final observations at Gurhagarh on the 20th April ;

At Siraoli I first saw the heliotropes shining down from the snowy peaks of the Pir Panjal. The snow at that time extended so many thousand feet below the summit...that it was not easy to imagine that men were residing there, the only indication of life...being the bright point of light shining from the apex of a noble snowy cone with that intense...light peculiar to a well served heliotrope, a sight not easy to be forgotten. ...

For the few days that I was there the great snowy range, 70 or 80 miles distant, was visible during the whole day ; not a cloud went near it, but with this exception the observations to these lofty peaks have invariably been hindered by clouds which...gathered about them one or two hours after sunrise. ...

From Karchunt the party went down to the Chenab and crossed over that river by means of the hemp ropes between Kethra and Ramban, then across the Soonkota Range...and up the Bichtari river, a fine dashing stream of clear water that tumbles into the Bannihal river some five miles below Kunchi. ...

Some delay occurred...on account of the great distance...for the back parties to...take up the points ahead in the valley of Kashmir. No direct road was available, and they were obliged to go by the Bannihal Pass. After the few days delay...the party ascended and encamped on the eastern peak...marked Ahertatopa H.S. From this peak we had our first view of the valley of Kashmir. ... The rice-fields were flooded and the valley looked somewhat like a large shallow lake dotted with islands, the latter being the clumps of trees round the villages, pretty to look at but inconvenient for the surveyor, as they seldom allow him to see the kalis[1] of the village, though he may be sure there is one.

The ascent of Ahertatopa is rather easy. I... made up a portable lightening conductor for the protection of the instrument. No iron being available...I was forced to splice the mining tools, crowbars, etc., together, ... forming...three points at the bottom. This conductor I pitched in the snow...close to the observatory tent. ...

I several times heard the crackling noise going on whilst we were in a cloud. ... On a former occasion...the duffadar told me he had his hair set on fire by it, and that the corner of the platform was knocked down and the door of the lampbox wrenched off its hinges. Certainly I had to repair both when I visited the station. ...

Just before we left this station Mr. Douglas happened to put up his umbrella to keep off some uncomfortably large hail stones, when to our astonishment it began to make the same kind of crackling noise, and on shutting it down all the points coming together it fairly hummed, and I thought it a rather disagreeable thing to handle. ...

The observations at Ahertatopa were completed in three days. More peaks of the great snowy range came into view, and all remarkable ones were laid down, including...the well-known peaks Ser and Mer—or Nanu and Kanu—Baltal, and even the Nanga Parbat, or Dayamur [88 n.3], at a distance of 133 miles. ... The plains of Hindustan were not visible.

From Ahartātopa Montgomerie moved on to Muli and had hardly got his tents and the lightening conductor set up when

a severe storm came on, first with a strong wind threatening to throw everything down from

[1] *Kālash* = temple spire.

the ridge, and then with a fall of heavy hailstones. ... About 4 p.m. snow began to fall, and about 5 p.m. the lightning and thunder seemed to be on the peak itself ; ... The small iron stove in my tent began to crackle in the most unpleasant manner ; ... the hair of my dog crackled, and in the dark sparks were quite visible. ...

Fortunately the instrument was in its box...as it would not have been possible to have reached the observatory tent in the dark. A good deal of snow fell, but...added much to the comfort...by blocking up the crevices and keeping out the wind. ...

Early on the 5th of June, I had a splendid view. ... The great snowy peaks bounded 90° of the horizon. The view towards the plains was magnificent, and...a large portion of Kashmir was visible. The houses in...Srinagar could be made out with a telescope though more than 40 miles distant. ... With the first touch of sunshine the clouds seemed to spring out of the upland vallies...and gathered round the higher peaks. ... Soon the peak we were on had its own cloud and...we saw no more of its brother peaks. ... Still the lower stations had sunshine and the principal observations to the heliotropes were but slightly interrupted.

The camp was in...sloping snow...connected with the platform by a very narrow ridge of snow...giving just sufficient room for the feet. On either side it was all but a precipice, the communication between the observatory tent was consequently not easily kept up, more especially at night when the surface of the snow was frozen and slippery. However, with the aid of a lantern Mr. Douglas and I made our way to and from the observatory. ... By 3 p.m. on the 6th I had completed all the observations, and was able to leave the peak.

Duffadar Moolee, a native of the plains of India, never failed me ; his heliotrope was to be seen whenever there was the least gleam of sunshine on the peak. At night his lamp was always of good colour, bright, and evidently well trimmed [222 n.5].

By the middle of June Montgomerie had completed observations across the Pir Panjāl[1] and he then worked down through Islāmābād to observe at Khārapur ;

This station was finished on the 18th of June, just before the rains set in. ... From Karpur I went to Churu H.S., a high station seldom free from clouds. From this time to the end of the season the work was greatly delayed from the clouds, mists, and rain, and at Gogipatri H.S. 32 days elapsed before all the observations were taken. The weather still continuing to be so bad, I marched the party into Srinagar. ... I reached the city on the 21st July. Mr. Johnson joined me shortly afterwards.

We remained in Srinagar about three weeks, taking the field again early in August. The weather had not, however, even then improved, ... and I was...obliged to spend a long time at Zebanwan H.S. [pl. 14]. ... I finished the final work for 1855 on the side Zebanwan H.S. to Gogipatri H.S.

Johnson meanwhile ran a minor series northwards up the Liddar to cross westward into the Sind and down that river to close near Srinagar ;

This expedition was a most arduous one, and...will prove very valuable as...correcting... a piece of country that has...been but vaguely marked on the maps, few people having wandered over it. Mr. Johnson had to cross numerous glaciers and ascend many high peaks. ...

I proceeded with Mr. Douglas down the Jhelum to Baramula, and then along the left bank of that river to Murree. ... Bad weather and paucity of trigonometrical points prevented me from taking in much of the surrounding country. This route is a very important one. The road is already very tolerable, and might with a little labour be a good hill road, and eventually laden camels might be brought into the valley by the same.

This Jhelum Valley road later became the main artery to Kashmir. In 1882 Dr. Arthur Neve rode along the bridle track from Murree to cross the Jhelum by a suspension bridge at Kohāla where cart-road construction had just started. The road from Bāramūla to Srinagar was open in 1897, and visitors then had a clear run from Rāwalpindi to Srinagar by tonga. Montgomerie continues ;

From Murree we returned to Kashmir. There Mr. Johnson rejoined me. ... I left the valley by the Pir Panjal Pass, sending Mr. Johnson by the Bannihal route. Some secondary work was done on the way. ... I divided the camp into two portions in order that we might see as many of the passes as possible. ... The Bannihal Pass, after the Jhelum route, is the lowest pass into Kashmir, but the route...is very rugged [228]; ... the Chenab has to be crossed in most awkward manner by ropes, causing great delay and trouble in the rains[2]. ...

At Achnoor I halted in order to have an interview with Maharaja Golab Singh. I reached Sialkote on the 1st of November, having thus been 8 months exactly in the Himalayas. ... I have to thank the Maharajah...and his officers for the ready assistance that was given me.

[1] DDn. 609 (237), TGM. to SG. 19–6–55. [2] now Ramban suspension bridge.

With but two surveyor assistants Montgomerie had accomplished a great task during this first field season, and brought back a wealth of new geographical material of high accuracy [229, 231]. The main series of principal triangles comprised three quadrilateral figures along meridian 75°, and then with a polygon swung north-west to Srinagar. From November to March the party spent the cold weather at Dehra Dūn employed on computations and mapping.

KASHMIR VALLEY, 1856

During the advance of the triangulation in 1855, Montgomerie and his assistants had kept up a rough quarter-inch sketch in no way sufficient for geographical requirements. Having no spare assistants trained for topographical survey the Surveyor General obtained the services of three military officers from the Quarter-master-General's department who joined Montgomerie early in 1856 [388]. In addition to these three—George Allgood, Charles Johnson, and Peter Lumsden—the party was further strengthened by the posting of William Beverley, who had one year's training in the drawing and computing offices at Dehra, and Elliot Brownlow of the Engineers. George Shelverton who had been one of the successful planetablers on the Himālaya survey joined later in the season [207].

Montgomerie reached Srinagar on 30th April, and sent Johnson out to cover the eastern end of the valley "with points at distances of from 8 to 10 miles apart" to serve the planetablers for half-inch survey [289]. He himself spent several weeks instructing his new officers before resuming the main triangulation[1].

> The Kashmir Series...left Dehrah on the 4th March 1856, reaching Jammoo on 11th April. ... I had previously selected the neighbourhood of Islamabad as the most suitable for...teaching the D.A. Quarter Master General the system of topographical drawing [208–9, 211, 288–9]. There were the hills above the Martund (the temple of the Sun) [IV, 291], the broad plateau...of Islamabad, so characteristic. ... There were numerous villages, and a most complicated system of drainage wooded slopes, and cultivation ; in fact, every variety of ground. ... About the end of a month I was able to detach two of them to sketch different portions...for the final work. Early in May, I had a sufficient number of points to start Captain Johnson also. ...
>
> I was able to commence the principal observations on the 1st of June. ... The rains obliged me to stop before the end of July. When the rains were at their height, I took up the computation of those points that were required for the next planetables. ... I inspected the work of all the officers...engaged on topographical sketches. ... The rains still continuing to be very heavy, I arranged to go into Ladakh, and made a reconnaissance of a portion of country, and set Captain Lumsden to work on a new planetable square.

When the weather cleared he made his first observations from Haramukh, the imposing mass that dominates the western end of the valley from the north.

> On the 6th of September...I commenced the ascent of the snowy mountain of Haramookh. After a march of 4 days I reached the station that had been built by Mr. Johnson before the rains set in. ... I encamped on the summit leaving, however, the bulk of my camp just below the limit of forest. ... This station is built on a sharp spur of the snowy peak of the same name. It is some hundreds of feet below the top of the peak. The highest point was abandoned partly in consequence of the refusal of the carriers to cross over the cracks of the glaciers that intervened between it and the present station, and partly because it was too exposed a situation for the lamp men. ...
>
> This station can be reached from Bandipoor on the great lake in four days. ... The station is about 16 miles to the east of Bandipoor[2]. ...
>
> I had the pleasure to see the various ranges of the Himalaya right up to Karakoram. There was nothing remarkable in the first 6 or 7 ridges. ... Beyond...came the snowy points of the Karakoram Range, and behind them I saw two very fine peaks standing high above the general range, ... possibly 140 miles away from me [87–9 ; pl. 6].
>
> The station on Haramookh is upwards of 16,000 feet above the sea[3], commanding a fine view of about 270° of the horizon. ... The platform is just above a fine glacier that slopes down

[1] DDn. 716 (64), Report for 1856, 26-3-57 ; printed at SGO., DDn. [2] ORO. Comp., Angle Book F/13-63. [3] Montgomerie's station 16,015 ft., *c.* 1½ m. NW. from summit, 16,903 ft., 1860 values.

into the tarn called Ganga Bal. Shortly after my arrival this glacier began to break away in huge pieces that thundered down towards the lake, throwing out clouds of pounded ice. ...

By two o'clock on the first day I had drawn out all the heliotropes on the other peaks except one, and that made its appearance in time to allow me to take two zeros before sunset on the 2nd day. During the 2nd night I completed all the observations to lamps. The moon was shining brightly. ... The glaciers, mountains, the great lake [Wular], and valley below looked magnificent. ... By noon on the 3rd day I had completed all the necessary observations, and before dark we had made our way down to the edge of the first birch forest, thus descending about 6,000 feet.

The Karakoram peaks were not seen again till intersected by Brownlow the following July and August from stations above the Deosai plains [89, 229], and Montgomerie now closed his observations for the season at Hant to the north-west.

This took me first by the great lake, and then for two marches along the road that leads to Scardo and Gilgit. This road is kept in good repair and has a godown and chowky at each stage. ... When the principal observations were finished, I...looked at the topographical work and carried on various computations, ... closing the field season about the end of October[1].

On completing his secondary triangulation at the east end of the valley Johnson had extended the main approximate series to the north till checked by the movement of the Māharāja's troops towards Gilgit [232], when he switched to secondary work in the Kishanganga valley; "The Maharajah particularly requested me not to advance towards Skardo till the force had returned".

Douglas was employed on minor triangulation southwards across the Pūnch hills from Bāramūla, and east towards the Pīr Panjāl Pass. Brownlow, after some months with Montgomerie, ran a minor series down the Jhelum. Shelverton reconnoitred the Māru-Wardwān valley[2] north of Kishtwār [227, 231, pls. 6, 11].

The three military officers were withdrawn to their units at the end of the season and the value of their training was lost to the department. They had completed some 3,200 square miles on the ½-inch scale at the eastern end of the valley and up the Liddar valley towards Kolahoi.

There had been one nasty accident. One of the best of the *dafadars*, Rāmdin, fell down a precipice in the Pīr Panjāl, and narrowly escaped with his life. "The scalp was dreadfully split and one eye completely gone. His back also and other portions of his body were seriously injured". He recovered only to be left "a sadly mutilated cripple" and was granted a pension [454][3].

KASHMIR & JAMMU, 1857–8

At the close of the second season, 1856, Montgomerie made a rough estimate of the area of the Māharāja's territories; first, on the Kashmir, or southern, side of the snowy range, where 8,000 square miles had now been completed; second, between the snow range and the Indus river; and last, to the north of the snow range so far as the Māharajah's authority might be found to extend.

I propose to survey the valley of the Indus on the ¼-inch scale on account of its general barrenness and scarcity of inhabitants, and also on account of the great expense...for a larger scale. The numerous villages and the comparatively easy nature of the remaining country renders the use of the ½-inch scale advisable.

The...progress for the planetablers has been taken at 2,000 square miles. ... In the valley of the Indus the total number of working months can only be four, on account of the great height of the mountains. ... For the triangulators I have also assumed 2,000 as the unit, because I think that 10,000 square miles is not below the average of a season's work for 5 surveyors when they have tolerable weather[4].

On this basis he estimated that the completion of the survey would require another four years, allowing 6 surveyors for planetabling and 5 for triangulation. The party was accordingly strengthened by several new assistants, and comprised

[1] DDn. 716 (64–5), TGM. to SG., 26–3–57, Report for 1856. [2] on ¼-inch map of 1859, Kudaran or Sunyan R.; on modern maps Burkol or Māru-Sudar R. [3] DDn. 696 (308); SG. to Mil. Dept., 6–4–57; 51 (20), TGM. to SG., 9–1–57. [4] DDn. 51 (19), TGM. to SG., 7–11–56.

for season 1857—triangulation, Brownlow, Basevi, Shelverton, Johnson, Douglas, Beverley—detail survey, three military officers from the Quartermaster-General's department, Austen, Melville and Murray [229] and four sub-assistants of the Great Trigonometrical Survey, Robert Bell, Neale, Baness, and George Scott, only Bell having had any previous planetabling experience [211, 428].

Of the triangulators, Brownlow was deputed to reconnoitre north-west "across the Kishenganga, and if possible over the Kaghan valley" to provide points "to the south of the Indus west of the Nanga Parbat", and to make junction with Robinson's survey of Hazāra. He was also to correct "our very limited knowledge of the mountainous country between Gilgit and Peshawar, including the course of the river Indus from the Nanga Parbat". He left Srinagar on 6th May,

and after a very difficult march, frequently up to the waist in snow, reached Shardi in Drawar[1] on the 15th, ... and has since reconnoitred the snowy range between the Nanga Parbat and Khagan, visiting the lofty snowy peak No. 21 of the Kashmir Series.

This reconnaissance was cut short by his recall to take over observation of the main series towards Skardo[2], and the triangulation of the Kāgān valley was eventually resumed in 1861 by Harry Thuillier, whom Montgomerie directed to

fix all peaks that are visible to the north, and if possible those of the Hindoo Koosh range. To collect geographical information as to all countries lying to the north of Khagan and along the river Indus, in order to add to, and correct, the imperfect maps of those terrae incognitæ, and if possible to define the course of the...Indus where it is unknown.

All doubt as to the identity of distant peaks is generally removed by visiting two points within 2 or 3 miles of each other, as the shape and relative positions of the peaks of a distant range do not differ materially at either end of such a short base. A third point at a distance ...must of course be visited before the peaks can be finally fixed [82, 221][3].

Shelverton was to triangulate the Chenāb valley eastward from the main series, fixing points for the detail survey towards Kishtwār, and making junction with Mulheran's work in Chamba [204–6]. He covered about 2,500 square miles of "the wild valley of the Māru-Wurdwān, and a large tract on either side of the Chandra-Bhāga between the Pīr Panjāl and the Chattardhar snowy ranges" [pls. 6, 11]. When rain stopped work he joined Montgomerie at Srinagar on 21st July, and returned to complete his area in September.

As work in the high ground to the north could not be started before the middle of June, Johnson first completed the detail survey of a difficult area at the eastern end of the Kashmir valley left over from the previous season, and then moved up to continue reconnaissance for the principal triangles across the heads of the Kishanganga and Astor valleys. He was much delayed by heavy snow, but by the end of July had selected and built four stations on peaks overlooking the Deosai plains in "Little Tibet" [232, 240]. He then established 9 stations "on lofty peaks on either side of the...Indus, thus carrying the series nearly to the junction of the Sooroo and Dras rivers" about 100 miles short of Leh[4].

Douglas was first to triangulate "the planetable squares" to the south of the Pīr Panjāl, through the foot-hills towards Mīrpur, and then to carry a series of minor triangles from the head of the Sind valley over the Zoji La into Ladākh, and down the Drās river to its junction with the Indus.

Your first duty will be to make a reconnaissance of the head of the Sind valley, and then to order the erection of staves...to carry the triangulation into the Dras valley. ... I wish you to sketch on the ½-inch scale that portion of the Sind valley...east of long. 75° 15′. The piece of country...is only valuable as lying on either side of the great road from Ladak to Kāshmir, and...the great essentials...are all that are required to be strictly accurate. ...

The object of this Dras Minor Series is to provide with...points for topographical work the whole of the country drained by the Dras River. ... The points should not be more than 12 miles apart and should be as conspicuous as possible. ...

On reaching the Indus, if the approximate series of the principal triangulation has not reached the junction of the Dras River, you must finish the series on conspicuous points that

[1] on Kishanganga, s. of Nanga Parbat [pl. 6]; photo. by G. A. Beazeley, *G.R. 1899–1900* (27).
[2] DDn. 716 (111–115), 9–6 & 12–6–57; 51 (34), 13–6–57. [3] DDn. 53 (63), TOM. to HRT., 3–6–61.
[4] DDn. 716 (130) (204); 1–7 & 6–1–57, 58.

can be easily taken up by the principal series. ... You must instruct your flagmen to erect conical piles of stones of as great a height as possible, but not less than 5 feet in radius and 9 feet in height. ... These piles might be capped with whitewash for 3 feet, so as to distinguish them from the isolated pieces of stone that abound in these hills [232]. ...

I wish to impress on you the importance of making all piles of stones over G.T.S. marks as strong and lofty as possible, so that they may remain conspicuous for years, even when the staff has been burnt up by lightning or otherwise removed. The expense of re-erecting the staves is always very great. ...

Whilst carrying on the triangulation it will be necessary to lay down as many of the high peaks in the neighbourhood as you can, selecting the most conspicuous, and re-observing the snowy peaks, d, e, i, f, j, x, and any other known peaks in the great range that may be visible. Vertical observations should be taken throughout, and all the usual rules...observed[1].

Douglas was not able to complete this programme, but made "a very neat sketch of a high piece of ground near the head of the Sind River", and carried "triangulation over the great snowy range that separates Kashmir from Ladak...by means of several stations on very high peaks" to a "short way beyond the fort of Dras". His death from an unfortunate shooting accident at Srinagar at the end of the season was a great loss to the Department [419][2].

Beverley made a planetable reconnaissance of the route from Achnur to Pūnch, and then "practised sketching on the ½-inch scale above the Lolab valley". After helping Montgomerie at Srinagar with the computation of points for the planetablers, he took up secondary triangulation on the western borders.

On Basevi's arrival from the Great Indus series he was directed to report on all the passes leading into Kashmir from the south between the Ferozepore Pass near Gulmarg on the west and the Banihāl Pass on the east. He was also to sketch on the ½-inch scale the main range between Apharwat Peak above Gulmarg and the Pir Panjāl Pass[3] [pl. 15]. The Surveyor General had pointed out that "Vigne mentions that the easiest pass into Kashmir said to be practicable for guns is the Banihal Pass [IV, 291 n.3 ; V, 224], ... but this is believed to be jealously kept from the knowledge of foreigners ; any passes regarded in this light should be surveyed with tact and caution". After surveying the passes Basevi was to

return by the Vedusta River [Jhelum] from Islamabad to Srinagar, and report on the said river between those places, and also upon the Dal, or City, Lake. Time and circumstances permitting you will report on the Vedusta from Srinagar to Baramula, including the Manasa Bal and the Wular Lake [231]. ...

Three barometers, two boiling-point thermometers, a planetable and a stand, are now placed at your disposal. ... One of the barometers and one of the boiling thermometers should be left in the city, and arrangements should be made to register...observations of them at some place, the height of which can be determined trigonometrically hereafter[4] [69, 236].

In September, he took a minor series down the Jhelum towards Muzaffarābād to provide points for planetablers not more than 8 miles apart.

Official news of the troubles in India reached Montgomerie on 11th June in a letter from the Surveyor General ;

You will...have heard of the mutinies...which occurred at Meerut on the 10th inst., and at Delhi on the 11th. ... Beyond the interruption of the post and disturbances caused by thieving scoundrels there seems to be no cause for alarm. ... Your party, I think, will be quite safe pursuing its peaceful avocations in His Highness the Maharaja's territory, and I would advise your going on with the work as if nothing had happened, unless you receive positive orders from the Chief Commissioner to come back. ... You will act on your own discretion[5].

Though he altogether under-estimated the seriousness of the situation in Upper India, the Surveyor General was correct in judging that Kashmir would be beyond the reach of trouble. Montgomerie himself thought it wise to remain in Srinagar to maintain touch with the Mahārāja's ministers, and "to procure the necessary assistance for his several detached parties". The large number of new officers and detachments also called for his presence at headquarters, and led him to recall Brownlow from the Kāgān to observe the principal triangulation northwards to

[1] DDn. 716 (119), 15-6-57. [2] ib. (204), 6-1-58. [3] DDn. 715 (285), 14-4-57 ; *GTS. Syn.*, VII (xliv-vi—C). [4] ib. (285), SG. to TOM., 14-4-57 ; 51 (29), TOM. to Basevi, 29-5-57. [5] DDn. 194 (9), 25-5-57.

the Indus. With Scott as recorder Brownlow set out from Bandipur on 18th June, observed at Hant two days later, and by September had closed observations just south of the Indus. Work was "much hindered by heavy clouds and haze" but he succeeded in getting rays to the Karakoram peaks which intersected with those which Montgomerie had taken from Haramukh [88–9, 226].

The plains of Deosai were a great obstacle...for, although the depression...gave a most extended view from very high points, still, there being no habitations for the distance of 7 or 8 marches, and no village of any size for 11 or 12 marches, the operations were carried on under very great difficulties [235–6].

In the plains the only firewood...is got by digging up the juniper roots, and from very thin stunted willows [234]. ... On the mountains...there was absolutely no firewood. ... The stations being all from 16 to 17,000 feet in height, it was absolutely necessary to reside for several days on these stations. ... The people of the country were, moreover, not very willing to enter the plains from the Kashmir side. The operations could only be carried on during the rainy season, and at that time there are but few breaks in the clouds which rush through...into the valley of the Indus and across the Karakoram mountains.

With the greatest difficulty the signal men...were fed, and on two occasions the main party were fairly starved out and had to retreat in consequence of protracted cloudy weather. Stations over 15,000 feet...are unmistakeably unpleasant, though there is some slight compensation...when the upper level of the clouds falls, ... leaving the camp on an island surrounded with a level sea of clouds from which the peaks...stood out like other islands, and the waves of clouds surged backwards and forwards across the lower ridges. ...

In clear weather the views were really magnificent. ... The atmosphere was at such times wonderfully clear. It was across the plains of Deosai that I took the first observation to the peak K-2 (28,287) at a distance of 136 miles. ... Notwithstanding all the difficulties, the triangulation was successfully carried over the plains during one season without relaxing any of the rigorous rules of the G.T.S.[1] [225, 231].

Further progress being stopped by winter conditions, Brownlow closed work, reached Srinagar on 20th September, and left three days later to join the Army at Delhi [483].

Good progress was made with planetable survey during the summer of 1857. "Lieut. Montgomerie trained his six new assistants who arrived gradually, the last coming in about the beginning of June. As the officers became fit to work independently they were sent out, ... and by the middle of June they were all at work"[2]. The military officers from the Quartermaster-General's department all did well [227].

Austen sketched a large area of rough ground along the Jhelum below Bāramūla, "detail unusually close but shown with great clearness". Melville worked in the high ground at the head of the Liddar and Kishanganga rivers. Murray completed three separate boards, the first in the hills to the west of the Wular Lake, the second in the highest parts of the Pīr Panjāl, and the third in the Chandra-Bhāga valley recently triangulated by Shelverton. Montgomerie reported after his inspection during August ;

Lieut. Austen's planetable is done in a very artistic manner, and though in a different style it expresses the ground as well as the sketching done by Captain Lumsden in 1856. ... His touch with the brush and accuracy of delineation makes his board the best that has been done during this season.

Lieut. Melville finished 95 square miles of very difficult and high ground at the head of the great eastern branch of the Lidur River though he was interrupted by rain and heavy clouds, and had to cut his way over the glaciers about the Shesha Nag lake. This piece of ground embraces more glaciers than any other board yet finished, with the exception of the board done by Mr. Douglas last month [228].

After instruction in planetabling between the Sind and the Lolāb, Bell and Neale then surveyed the south-west ridges of the Pīr Panjāl into Pūnch.

Half-inch detail survey for the six months came to about 6,500 square miles, of which the military officers had contributed from 1200 to 1400 each. Triangulation covered 21,000 square miles, and included 541 secondary triangles fixing control for

[1] DDn. 53 A (M. 393); memo. to Punjab Govt. by TOM., 6-3-61 ; cf. *GTS. Syn.*, VII (xxvii-ix—C).
[2] DDn. 716 (204), Report, 1856-7, 6-1-58.

the planetabling, but the most notable achievement was the fixing of preliminary heights for the Karakoram peaks, K2, 27,928 feet, K1, 25,416. "The former is an altitude never dreamed of by the travellers and savants who have seen those ranges. ... None indeed put these peaks down at anything over 24,000"[1]. It was in October 1857 that Montgomerie took his magnificent panorama of the Pir Panjāl [pl. 15] from the rocky hill of Takht-i-Sulaimān, or Sankarā-Chārya [IV, 291].

The season had an anxious start. Not only had there been the training of new officers and assistants, and the disturbing news from India, but also the serious illness of the Māharāja, who died on the 2nd August. He was immediately succeeded by his eldest son, Ranbīr Singh and there was no break in the friendly policy towards the survey. The Surveyor General warmly acknowledged

the cordial support received...at all times from the late Maharajah Goolab Singh. ... His successor Maharajah Runbheer Singh following the excellent example of his father...has also assisted the survey in every way. ...

Lieut. Montgomerie is deserving of all praise for the admirable manner in which he has kept his position in Kashmir, and maintained the most amicable relations with its Government during...the embarrassments caused by the illness and death of the late Maharajah. During the early part of the season he rendered great assistance to the Political Agent. ...

At the commencement of the season when the party had just reached Srinagar, a fire broke out in the city which...threatened to involve the palace and the whole capital in one universal conflagration. Lieut. Montgomerie with his establishment was able to render effectual aid in extinguishing the fire. ... His able assistant Lieut. Elliot Brownlow rendered himself most conspicuous by his activity and energy in the midst of the flames[2].

For season 1858 the first task was to complete the survey south of the great Himālayan range. Up to the end of June Montgomerie employed his three triangulators on secondary triangulation fixing points for the planetablers—Shelverton northwards from Jammu through Udhampur to the Chattardhār Range—Johnson eastwards from Jammu to Bhadarwāh [pl. 6]—Beverley along the Jhelum to Muzaffarābād on the lower Kishanganga, with connection to the Kāgān peaks. In July he reported the completion of the triangulation of the "Sub-Himālayan territories of the Māharāja of Cashmere", which he defined as lying

to the south and east of the great axis of the Himalayas, ... from the river Ravee and the glaciers of the Bramah Range on the east [236] to the glaciers of the Nanga Parbat on the north[3].

This province, by far the most valuable portion of the Maharaja's dominions, has an area of nearly 22,000 square miles, including all the hilly country drained by the Kishangunga river, —the valley of Kashmir—almost all the hilly country drained by the Jhelum—all, except the small districts of Laboul and Panga, drained by the Chenab—also a portion of the hills drained by the Ravee—as well as a rich tract of level ground at the foot of the hills between the Ravee and Jhelum rivers—...three snowy ranges and 250 miles of the Great Himalaya Range [pl. 6]. ... No less than 860...points have been fixed by means of about 1,800 triangles[4].

From July these three triangulators resumed work beyond the great range up the Indus and into Baltistān and Ladākh [232–3].

Planetable survey was distributed between the three military officers and two young sub-assistants. After spending the cold weather on map drawing at Dehra Dūn, Austen, Melville and Murray took up work in the Jammu foothills during February [232]. By the end of March, Austen had sketched 550 square miles round Jammu including "some very difficult raviny ground at the foot of the hills". He then moved up to the Chattardhar ridge, but was delayed "by the winter's snow and occasional fresh falls", and was later laid up for several weeks after being assaulted by unfriendly villagers [475–6].

Melville worked first in the lower hills south of the Chattardhar Range, and then moved west beyond Kashmir to the region of Tithwāl on the lower Kishanganga where by the end of May he had finished

his entire section of 490 square miles, including nearly the whole district of Kurna, which has not hitherto been visited by any European except Lieutenant Brownlow. ... Country...

[1] DDn. 716 (155, 204), Reports for Aug. and for season, 1857. [2] DDn. 643 (167), SG.'s Report, 15–10–57. [3] Brāma peak, 21,059 ft., & glacier, on Gt. Himālaya range some 30 m. s. of Nun Kun, draining into Māru-Wardwān valley [pl. 13]. [4] DDn. 716 (307), TOM. to SG., 18–7–58.

picturesque in the extreme, tolerably culturable, and possessing capital grazing ground, ... but to the north being very rugged. ... The inhabitants are very independent and acknowledge obedience to no one, not even to their own Raja[1].

In August he moved east to Padar in the Chenāb valley which had been triangulated by Johnson in May; his ground lay to the east of 76° and south of 33½°, and is drained by the Chandra-Bhaga before it is joined by the Maru-Wardwan River. ... Includes all the country drained by the Batnai River[2]. Lieut. Melville will...shew all the ground...beyond the boundary between the Maharaja's and the Chumba teritory, ... to prevent any difficulty about a junction with the survey of Chumba[3].

He later surveyed the area where Austen had trouble earlier in the season. It was a bad year for cholera, and Melville lost two of his followers.

Murray had started work on 24th February in the sandstone hills north of Jammu, and had then moved to western Pūnch "just to the east of Murree sanatorium", and then in the direction of Kāgān. In September he was transferred to Robinson's party in the Punjab.

Edward Ryall and Todd joined from Robinson's party early in June 1858, and after instruction near Srinagar took up work towards the Chamba border on the east. Except for about 700 square miles[4], the provinces of Kashmir and Jammu south of the great range had now been surveyed on the ½-inch scale, in 22 field sections. During the cold-weather months of 1858–9, these were mapped at Dehra Dūn to form "The General Map of Kashmir Proper" [238] that was despatched from Dehra at the end of May 1859, with a full account by Montgomerie;

Kashmir is a large valley lying between two snowy spurs of the Great Himalaya Range, drained by the river Vedusta or Jhelum, which with its tributaries is navigable by large boats for about 90 miles. The greatest length of the valley from ridge to ridge...south east to north-west...is about 118 miles. The flat portion is about 89 miles long, with an average breadth of 16¾ miles, elevated about 5,200 feet above the sea. ...

The lower level is subject to inundation, and indeed the portion between the city and the great lake still forms one vast marsh. ... The mountains around Kashmir are covered with snow for at least 8 months in the year, many being from 15,000 to nearly 18,000 feet above the sea. ... Special arrangements were required...for the necessary supplies of food and wood when the surveyors were working far above the villages. ...

Though the country...was so elevated the rigorous rules of the G.T. Survey were adhered to throughout [229]. ... On the principal series...the observations were invariably made to luminous signals [222]. ... Numerous observations being required, it was necessary for me to reside on the peaks for at least two days and nights, generally more. ... Occasionally ...the party had to remain pitched on the snow for upwards of a week [223–4]. ...

By...principal and secondary triangulations the whole country was covered with trigonometrical points at an average distance of little more than 4 miles from each other [119, 289].

The topographical detail was sketched in the field on planetables, ... an arduous task in such an elevated country, as it was...necessary to visit numerous peaks and...ridges in addition to the trigonometrical stations. ... The drawing of the field sections expresses the ground well, that of Lieuts. Lumsden and Austen being more especially artistic. ...

There were many difficulties peculiar to surveying in a partially independent State. The natives of the country, moreover, had prejudices against going up some of the high hills, but the clouds, mist, and haze, were always by far the worst enemies of the surveyors.

The Kashmir map embraces 8,100 square miles, with no less than 4,606 villages depending upon 352 trigonometrical points. The cost has been about Rs. 4–5–2 per square mile[5].

Montgomerie found the local name of the Jhelum River spelt in several ways; I suppose you have already printed *Vadusta*. If you have, add *or Behut*. The latter is, I am told, a corruption of *Vadusta* which is spelt indifferently *Badusta* or *Vadusta*. I tried two munshis. ... One spelt it with a *B* and the other with a *W* or *V*; ... one used *d* where the other used a *t*[6].

A list of the *parganas* of the Kashmir valley was attached to the map;

After Acber took possession of Kashmir [1589 A.D.], his dewan Todamul [1: 153–5] proceeded to divide the valley into pergunnahs. Thirty-three pergunnahs were formed by

[1] DDn. 716 (295), Report for May 1858. [2] joins Chenab, from N., sheet 19, pl. 6. [3] DDn. 716 (322, 371), 14–8–58 & Sept. [4] nr. Jammu and in Kishanganga valley [232]. [5] DDn. 717 (27), TGM. to SG., 30–4–59. [6] ib. (45), TGM. to W. H. Scott, 20–5–59; also *Vitasta*, Stein (82–7); Ferguson (112, 129); *vitasti* = hand span, the fabled width of spring at source.

grouping the villages together in a convenient manner. The village of Patan was, however, omitted. When the mistake was pointed out to Todamul he ordered the village to be made into the 34th pergunnah by itself. ... Subsequently...the Diwan wished to make up two more pergunnahs so that there might be a total of 36. ... Salimoza Bala to the south of the city, and Salimoza Paieen to the north. .... In the Sikh time 4 more pergunnahs were made[1].

The small areas near Jammu were cleared up in the spring of 1859. Austen surveyed the low sandstone ridges of districts Samba and Jasrota before rejoining his regiment in England. Melville completed a similar area further east, and then joined Montgomerie in Srinagar. During May he and Ryall spent ten days instructing new assistants in planetabling north of Srinagar, and then took them out for survey of the upper Kishanganga, "a...precipitous chasm in the mountains".

This had to be taken up when the snow was heavy, even at 9,000 feet. This added very much to the difficulties...but, as the Maharajah's troops were shortly to cross the valley en-route to Gilgit, it was necessary to finish early [226]. The work was completed in very good time, and the...surveyors were then transferred to fresh ground in Little Tibet and Ladak.

The close of this Kishanganga work in June completed "the southern slopes of the Himālaya that belong to the Māhārāja".

During May and June, after Beverley had fixed a number of extra trigonometrical points, Melville and Ryall surveyed the "fort and city of Srinagar on the scale of 2 inches to mile, forming a handsome map" [239–40 ; pl. 14][2].

BALTISTĀN & LADĀKH, 1858–61

Survey to the north had been started in 1857, when Johnson laid out the principal triangles and Brownlow had observed the final angles across the Deosai Plains up to the Indus. Whilst the survey of Jammu and Kashmir was being brought to a close during 1858, Montgomerie sent his triangulators forward on "a new survey...of Ladak and Little Tibet"[3]. This term, Little Tibet, had long been applied to the country of Baltistān, which lies immediately north of Kashmir and extends across the Deosai Plains and astride the Indus to the Karakoram Range, with Skardo[4] as its capital [1 : pl. 8 ; IV, 290–1 ; V, 147, 227, 239 ; pls. 5, 13]. Its origin and significance is described on a later page [240].

At the end of June 1858, Shelverton[5] was sent north to carry forward the principal series from Brownlow's stations overlooking the Indus. He was to observe the polygon round Skardo, and then advance towards Leh, with stations on either side of the river. Montgomerie gave instructions for the observation and designation of snow peaks and for fixing secondary points for topographical work. He recommended whitewashed cairns as used by Douglas the previous season and by Walker on the Peshāwar survey "when observing to low from high ground [216, 228]". Shelverton started work at the end of July and closed on stations just above the junction of the Drās River. His observations to the Karakoram peaks brought the height of K 2 to be 28,287 feet above the sea [89 ; pl. 6][6].

Johnson[7] was directed to extend the main approximate series to Leh, and then to triangulate the Shyok river "starting from its junction with the Indus" ;

The primary object of the Shyok triangulation is to cover all the country drained by that river with sufficient...points for the topographical work. Provision should be made for the triangulation of the larger tributaries...which will be taken up after...the main stream. ... Your attention should be more particularly directed to peaks east of 77° and north of the Shyok. Points on the extreme east will be very valuable.

A reconnaissance on the ¼-inch scale should be carefully made, giving as many villages as possible. Enquiries should be made about all roads to Yarkund, about the names of the serais[8], as well as of the ranges of peaks. All information about Yarkund, Shigar, and Hanazī Nagar should be written down[9].

[1] DDn. 717 (48), 24–5–59 ; cf. Stein (133–6) ; Ferguson (38). [2] DDn. 652 (5) & 717 (182), 6–10–60 ; Report 1858–9 ; MRIO. 183 (30) ; 1-inch reduction, GBO, Lib. D (4). [3] DDn. 716 (361), TOM. to Punjab Govt., 30–11–58. [4] local form preferred to Skardu of official maps. [5] with Neale as recorder. [6] *GTS. Syn.*, VII (xxi—C). [7] assisted by Scott. [8] staging shelters. [9] DDn. 716 (310), 10–7–58.

Part of the KASHMIR VALLEY
(overleaf)

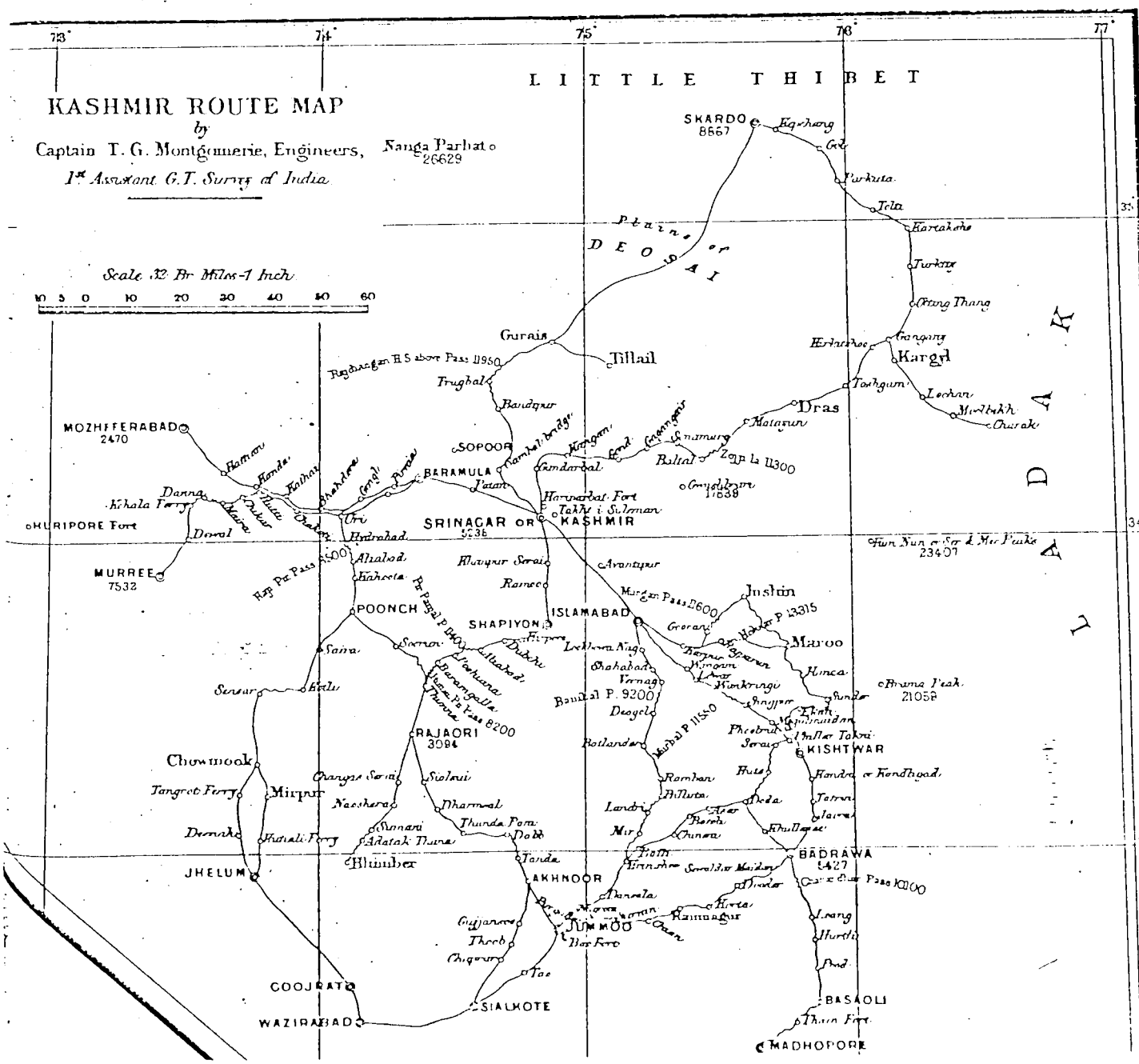
from Montgomerie's ½-inch survey of 1856–7

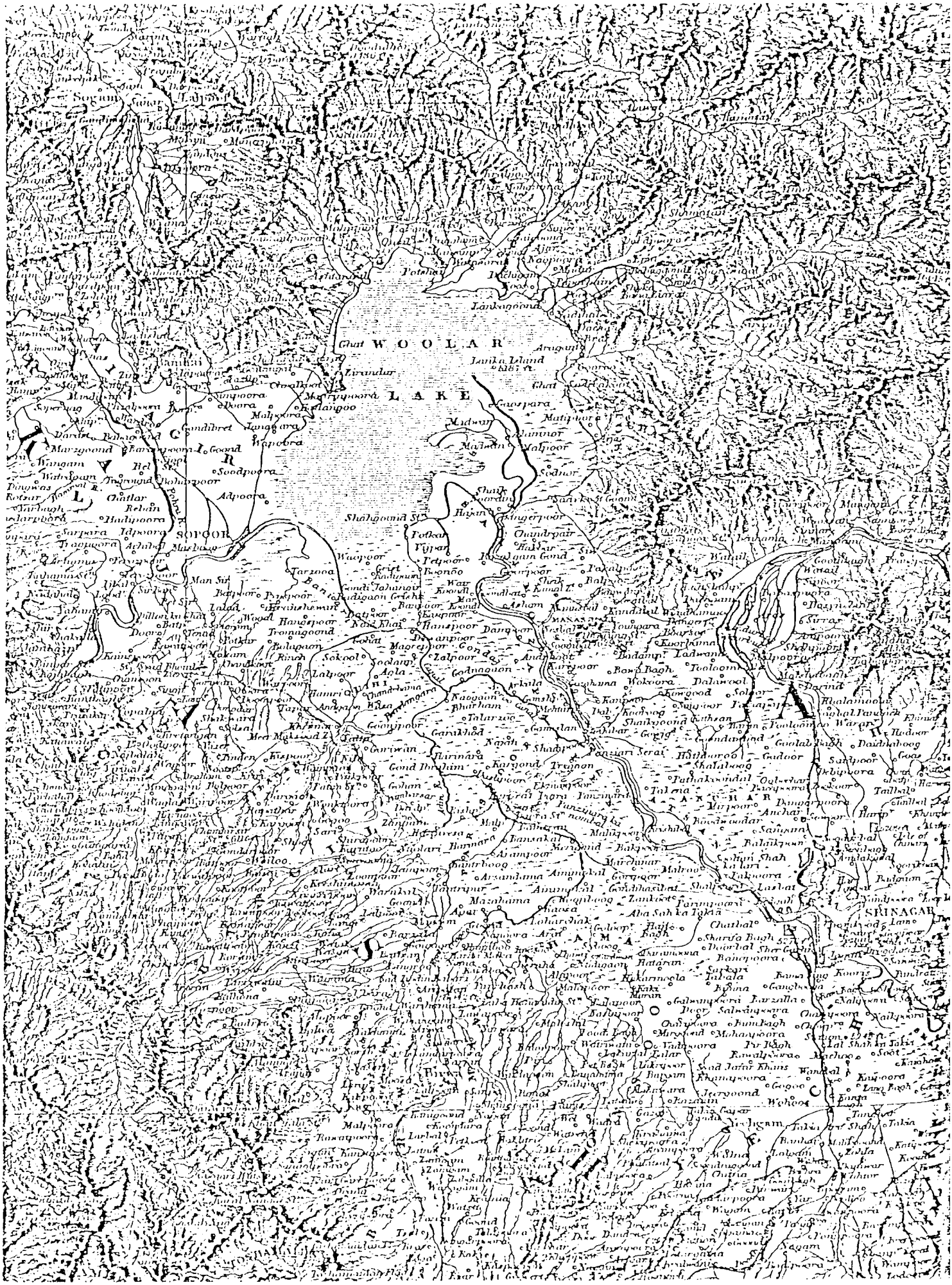
From sheet 28 of Atlas of India, published by
John Walker 1867, scale 4 miles to an inch.

Route Map lithographed at S.G.O., Calcutta
1860, a second edition following in 1862.

T.G. Montgomerie

R. Scott Waugh




W O O L A R
L A K E
SOPOOR
SRINAGAR

He started on the Shyok series on 4th September and "though hindered by bad weather observed at three high stations before closing for the season". His assistant Scott advanced the main lay-out up the Indus.

Beverley extended the Drās minor series started by Douglas [227–8] to close on the main series, and then observed at twenty stations westwards up the Shingo valley towards the Deosai Plains, "in very elevated ground" [pl. 6].

The completion of the Kashmir map delayed the start in 1859, and the party did not reach Srinagar till 11th May. As field work now lay all to the north the late start suited well. The strength had been much reduced, and only Melville and Ryall were available for planetabling. Shelverton remained at Dehra working on the General Report till he took over charge of the Gurhagarh Series [51].

Johnson spent May on the upper Kishanganga and then carried forward the main series up the Indus, sending Scott ahead on the approximate series. He was to give special attention to the snow peaks [88], and to

the names of stations with their provinces, pergannahs, etc. ... If possible Le, the capital of Ladak, should be fixed from the principal stations.

The approximate series is to be pushed up the river...in continuation of last year's work, with stations in the hills on either side of the river. This series will for this season only extend as far as the Zaskar River. The stations near the Zaskar must...give suitable bases for the extension of the triangulation up both the Indus and Zaskar rivers. ...

Two or three stations must also be selected in the ridge between the Shayok and the Indus in advance of the Zaskar River...to command a good view of all the peaks about the head of the Shayok River. ... A careful reconnaissance on the ¼-inch scale to be made[1].

Wintry weather compelled him to close work in September ;

In consequence of stormy weather and the extreme cold which the native lampmen could stand no longer, the work had to be closed a little earlier than usual. ... The weather at the beginning of September was very stormy, ... and similar weather continuing at short intervals made it too cold on the higher peaks for the native heliotropers to remain on the stations till the end of the month. The thermometer in the day time was often as low as 15° Farh. The weather generally during the field season of 1859 has been very unfavourable[2].

Scott brought the approximate series to its terminal stations beyond Leh by the middle of July, and then ran a minor series up the Zānskār valley for topographical purposes.

After triangulation beyond the Zoji La to provide points across the upper Drās and Suru valleys, Beverley extended the main series towards the head of the Indus.

The general object of the Upper Indus series is to cover with G.T.S. points for topographical purposes all that portion of the Maharaja's Ladak territory that is drained by the river Indus before receiving the Zanskar tributary. ...

A single series of symmetrical triangles...will be sufficient, with minor branches for the Hanle and other large tributaries that there may be between Leh and the Chinese frontier. ... The Upper Indus series forms a most important section of the Kashmir Series [pl. 6]. ...

Mr. Neuville will accompany you...till it is necessary for him to join Mr. Johnson, whom he is ultimately to assist in the observatory[3].

After sending out his triangulators Montgomerie himself set out to Ladākh, taking Melville with him[4]. He travelled up the Sind, crossing

the Zojji La, the Ummyika La, Photo La, and other passes. En route to the first some snow was encountered and a road had to be cut with hatchets, but further on—tho' the passes were higher—no snow was met with until after passing Leh. ... At Kargil, the largest place in the Sooroo valley, Lieut. Melville commenced his work.

After completing about 500 square miles of ¼-inch planetabling during July and August, Melville "was laid up from over-exertion and forced to get medical advice". He spent the rest of the season at Srinagar on light duty, joined by Ryall who also had fallen ill whilst on detail survey on the Upper Kishanganga. Montgomerie continued his tour and,

after reaching the Indus River, ... had in consequence of the height of the river to march by an upper road with a low range of 14 or 15,000 feet between him and the Indus.

[1] DDn. 717 (53, 56), TO M. to Johnson, 30/1-5-59; properly Zānskār, from Tibetan, meaning "white copper" [205 n.5]; DeTerra (21 n 14); *HJ.*, XXII, 1959–60 (84–94). [2] ib. (96), 3-10-59. [3] DDn. 717 (59), 7–6–59. [4] Melville & Ryall had completed their svy. of Srinagar town [232].

After inspecting the triangulating party under Mr. Beverley and...the approximate series under Mr. G. Scott, ... Captain Montgomerie pushed on to make reconnaissance of the upper part of the Indus and of the so-called tableland of Roopshoo. ... Spent the end of July and the beginning of August in Roopshoo, and reconnoitred as far as the great Chomorari Lake [Tso Morari], ... a splendid sheet of water perhaps 20 miles long. ...

Roopshoo...consists of a series of lakes, or the beds of what have...formerly been lakes. From these, which are generally at or over 15,000 feet, mountains with tolerably easy slopes rise up gradually to some 18,000 to 19,000 feet. ... To the south of Chomorari Lake they rise perhaps to 21,000. The lakes...are generally landlocked, receiving rivers and discharging nothing. They have become more or less salt. A want of drinking water is consequently one of the traveller's difficulties [235].

Captain Montgomerie hopes that the triangulation will be successfully carried up to the Chinese frontier and south of the Himalayan ridge, though the country remaining...presents truly formidable obstacles. ... Fuel...gets scarcer and scarcer. ... At first willow sticks about the thickness of the thumb were to be got, then furze-bush roots had to be dug out, ... and finally near the Chinese frontier nothing except cowdung was to be had, and the greatest care was necessary to select a place for encampment where Tarters had formerly been[1] [236].

For season 1860, Montgomerie had fourteen assistants—triangulators, Johnson, Beverley, Clarke, Neuville, Scott, and H. E. T. Keelan—planetablers, Austen, Melville, Bell, Ryall, Todd, Low, Atkinson, and Bolst. He left Dehra on the 8th March, reached Jamoo on the 10th of April, and Kashmir on the 30th. ... During February and March there was a great deal of stormy weather during which immense quantities of snow fell in the mountains. ... This snow is still [June] very heavy on the hill sides, and has given a great deal of trouble during the whole of May. ... Even on entering Kashmir the party had a good deal of trouble in crossing the Pir Panjal Pass. ...

Captain Montgomerie put the new planetablers to work on a large scale, and...preparations were made for taking up work in the Kishanganga [233]. Each new planetabler was attached to one of the old surveyors with a duplicate board. ...

After starting the topographical surveyors on their work, and drawing up instructions for an extension of the Kishangunga triangulation, Captain Montgomerie commenced latitude observations at Poshkar H.S., and though much hindered by stormy weather finished the observations by the 28th of May. Capt. M. then took up latitude at the Gogipatri H.S.[2]. As a result of these observations made "to determine the amount and direction of attraction" Montgomerie found a southerly deflection of 22″ [132–3, 137 n.1][3].

Having prepared the large number of planetables "required for the topography", and sent the triangulators off to Ladākh—"the first party leaving on the 12th [Johnson], and the second on the 19th June [Beverley], and so on in succession as fast as the carriage available would admit"—Montgomerie started for Ladākh himself with Scott as assistant. Scott unfortunately "fell sick at the foot of the Zoji La", and had to return to Srinagar, where he got into very serious trouble and had to resign from the Department. This troublesome business compelled Montgomerie to break off his tour and hurry back to headquarters.

Johnson's first task was to make the final observations at the last three stations just beyond Leh. He then commenced a minor series from the Indus to the Baralacha Pass, crossing the tableland of Rupshu and the upper part of the Zanskar district, ... appropriately called the Rupshu series. ... The main object...is to cover the whole of Rupshu and as much of the upper part of Zanskar as possible with...points for topographical work. A junction should...be made with...the North-West Himalaya series [202–4]. ... Junction with the Zanskar triangulation will be necessary [233 ; pl. 6][4]. He completed this connection during the two seasons 1860, and 1861 the discrepancy at his junction with the work of 1851, coming to 0·63″ in latitude—0·28″ in longitude—and one foot in height [202, 286]. It was from this triangulation that he fixed points along the 21,000 foot crest running north of the Spiti valley[5].

Beverley was to extend his Upper Indus series, but to "be careful to prevent all collision with the Chinese authorities ; ... your advance parties should avoid

[1] DDn. 717 (82), Report, July & Aug., 1859; ib. (182), season 1858–9. [2] ib. (155), 19-6–60. Report March-May, 1860, Poshkar 34° 2′; 74° 30′; 8,337 ft., 20 m. from Srinagar and 7 m. E. of Gulmarg. Gogipatri now Gogajipathar; 33° 51′; 74° 39′; 7752 ft. [3] Burrard found these deflections "not reliable", *GTS.*, XVIII (531). [4] DDn. 717 (713), 13–5–60. [5] including "rocky point" Parangla 2 [203], bt. 23,050, from single intersection and single vertl. angle, obviously misidentified [82, 91, 221, 506 n.4].

the inhabited portions of the Chinese territories". During June he had observed 15 triangles and visited the very lofty station of Pashusphu H.S., 19,572 feet above the sea, perhaps the highest from which regular observations have been hitherto taken"[1]. During 1861, he completed the series eastward to longitude 79° and then swung south to cover Hanle [pl. 6][2].

The heights of the peaks occupied were deduced

from reciprocal observations, and in no wise depending on the uncertainties of the barometer or thermometer. ... Johnson twice observed at...19,979 feet[3] and Beverley at 19,958. ... A trigonometrical mark was erected on a point 21,480 feet, but unfortunately there was not sufficient space to put a theodolite on it. ...

The group of peaks beyond Shayok which Captain Montgomerie saw from Rupshu last year have turned out to be over 26,000. ... Further observations have been taken to K2, ... height being about 28,267 feet above the sea, there being as yet but one mountain in the world known to be higher, viz., Mount Everest [88, 92][4].

Montgomerie claimed that amongst the distant peaks fixed was, presumably, "the great Gya Peak, probably from 23 to 24,000 feet above the sea"[5].

Clarke took up the Zānskār minor series, following "the Zanskar River from its junction with the Indus to its source near the Bara Lacha La". Neuville, after having fixed points in the Kishanganga valley, extended the triangulation of the Shyok and Nubra that had been started by Johnson in 1858, "carrying his series over the lofty ridge that separates the Indus from the Shayok by means of some very high stations over no less than 19,700 feet".

After completing the ½-inch survey of the Kishanganga valley [232] by June 1859, the planetablers were all moved to start the ¼-inch survey of Little Tibet and Ladākh. Melville "sketched the greater part of the Sooroo and Dras vallies, including some very difficult ground near the Kun and Nun peaks which are surrounded with great glaciers, ... as also a very difficult piece of the Wardwan valley [226–7]". Joined by Bolst in 1861, he reached the Bāra Lācha Pass, following Johnson's triangulation. He took a number of photographs of glaciers and picturesque rocky scenery in the Zānskār and Padam region [141]. Todd, who during 1860, had been kept in the Kishanganga valley, moved in 1861 to eastern Ladākh to sketch the high table-land and salt-water lakes of Rupshu. The Tso Morari was found to be 16 miles in length, and 2 to 3 miles in breadth surrounded by bare mountains rising 5,000 feet above the lake to 20,000 feet above the sea. Herds of Tibetan antelope and the *kyang*, or wild ass, were common on the stony slopes, and the waters teeming with duck and geese [234][6].

During 1860 and 1861 Bell surveyed up the Indus towards Leh. Ryall surveyed the Shyok and Nubra gorges and the wild mountains they drain, whilst Bolst's "delineation of the plains of Deosai is both characteristic and artistic". Austen rejoined from England in June 1860, and sketched the terrific slopes of the Karakoram northwards from Skardo. He continued westward astride the Indus during 1861, through the Astor and Shigar valleys, and ascended the Baltoro and Biafo glaciers, pitching camp on strips of moraine[7] [89]. During 1860

topographical sketches were made of the whole valley of the Indus from Skardo to Leh, as well as the whole of the Sooroo and Dras vallies, the plains of Deosai, and a large part of the Shigar valley north of Skardo, with a portion of the Nubra or Shayok valley.

This large tract, ... in all about 12,000 square miles, had been triangulated in previous seasons, and ranged from an altitude of 27,000 to 8,000, though seldom under 10,000. It included nearly 400 square miles of glacier. Captain Austen's ground rose to nearly 27,000 feet, and one of the glaciers is about 11 miles in length and from ½ to 2 miles in breadth. In Lieut. Melville's work the peaks run up to nearly 24,000, and under Kun, the highest peak, one of the glaciers is about 10 miles broad. ...

The plains of Deosai are, perhaps, the most curious topographical feature...sketched during the season. They consist of about 580 square miles of gently undulating ground, averaging

[1] Johnson obsd. at Nela H.S., 19,036 in June 1854 [208]. [2] MRIO. 114 (42), Beverley 1860, towards Hanle. [3] and at 20,600 in 1861. [4] DDn. 717 (274); 51 (88), Report for 1860. [5] Modern maps show a Gya peak, 22, 290 ft. 20 m. S. of Tso Morari. [6] Todd's svy. pub. *Roorkee Papers*, CXXVIII (402); *GTS. Syn.*, VII (XIX-ii—C); DDn. 51 (50), Report 1860, TGM., 20–4–62. [7] one PT. section now in svy. museum at Debra [489 n.7].

at least 14,000 feet above the sea, surrounded on all sides by rugged mountains running up to from 16,000 to 17,000 [229].

During 1860 the party completed 13,500 square miles of triangulation and 12,160 miles of ¼-inch topography[1] whilst for 1861, the outturn of triangulation, came to 12,000 square miles, and of ¼-inch sketching, about 14,500;

Triangulation was extended over...Zanskar, Rupshu, and that part of the upper valley of the Indus near Hanle which belongs to the Jumoo Maharaja. Points were fixed along a great part of the Chinese frontier, and some stations were fixed within Chinese territory.

On the west the triangulation was extended across the Khagan valley [227], and from its northern ridge several peaks were fixed beyond the Indus, a few to the north of Swat, and one probably just to the south of Chitral. ...

The topographical work progressed admirably in Little Tibet, on the Shyok River, in Zanskar, Rupshu, and the upper valley of the Indus, covering a large area of difficult and very elevated country traversed by gigantic glaciers. ...

Beyond the Himalayas the snow has been less than on...the outer ranges, but on the other hand there has been a great increase of hardship from the sparseness of the population, and from the difficulty of procuring food and fuel, the latter being particularly felt. ... For a time the surveyors have been entirely dependent on yak and other dung for fuel, occasionally aided by the thin roots of the Tibetan furze which can be grubbed up here and there [229, 234].

At first the population...could all understand Hindustani, but latterly hardly any of the inhabitants have had the least idea of that language, and communication in Little Tibet and Ladak has been necessarily carried on by means of interpreters. ...

The heights of all important passes, ...towns and villages, of junctions of streams, and obligatory points...have been determined.

On the Brumah Range one glacier was found to be 11½ miles long, another 9½, and...many more between 5 and 7½ miles in length [235]. In Sooroo valley the Purktsi glacier was found...7½ miles long, ... a wonderful torrent of ice that tumbles down the side of Nun Kun peak, which rises to over 23,000. ... In Zanskar the largest was the Drung-Drung glacier, 15 miles in length. ... In the Mustagh and Karakoram range one glacier has been found 35 miles, another 24 miles, in length. ...

Captain Montgomerie had to train a...number of surveyors, and—more especially in topographical work—an entirely new staff of assistants who...were again all removed, ... and a third set had to be trained, and...training has now commenced for the fourth time. ...

The commissariat and financial arrangements...were in themselves very difficult. Food had sometimes to be carried 15 to 30 marches. Ready-money payments had to be made to the Tartars. The transmission of letters was not easy. Captain Montgomerie has had...to act with the greatest tact. ... All complications have been avoided, and the survey has consequently been viewed favourably by the Maharaja and his higher officials. ...

Barometers and boiling thermometers have been in constant use, and a great number of observations have been recorded at all heights. ... From these...Captain Montgomerie hopes to be able to deduce some general rules, as in many cases these observations have been taken at stations whose heights are known from the trigonometrical work [60, 228, 238]. ...

If the weather is favourable, and the effective strength...remains the same, ... the work... may be brought to a close in at least two seasons more[2].

TRANS-HIMĀLAYA, 1862–5

For 1862, Montgomerie's staff was reduced to Johnson, Beverley, and Clarke for triangulation, Austen, Melville, Ryall, Todd, Low and Bolst for detail survey.

Johnson and Clarke were to run a series of triangles eastward from Leh to the eastern end of the Changchenmo valley, with a branch up the Shyok valley towards the Karakoram Pass. The object...is, 1st., to cover...all the Maharaja's territories...east of longitude 78° and north of latitude 33° 45′, and 2nd, to fix as many points as possible in Chinese Tartary towards Ilchi, the capital of Khotan. ... The peaks in the eastern continuation of the Karakoram Range will be more especially the object of your attention. ...

The triangulation should be named the Changchenmo Series, and all peaks and points without names should be recorded as E1, E2, E3, etc. ... You must be careful to prevent all collision with the Chinese Tartars on the common boundary[3].

[1] DDn. 53 A; M. (393), 6-3-61; DDn. 717 (271-4), Report 1859-60; *JASB.* xxx (99-110); DDn. 21 (12-26), 21-1-61. [2] DDn. 51 (88), TGM. to STS., 1861. [3] DDn. 53 (304), 24-3-62.

Johnson carried this series about 100 miles—the average height of stations being 19,877 feet—and fixed peaks in the Kuenlun mountains to the north, including E 61, 23,890 feet. He then spent the whole of 1863 in recess at Dehra Dūn, his first respite from strenuous mountaineering for nine years.

During 1862 and 1863 Beverley triangulated the Astor valley and cut in "numerous peaks...in the ranges beyond Hunza and Nagar", whilst in 1863 Clarke connected up the Zānskār and Rupshu triangles.

On the detail survey Austen worked up the Changchenmo and with Pullan sketched the Pangong Tso and its string of lakes. Melville's health broke down again [233] both seasons, but Ryall sketched a large area of the desolate plain of Lingzi Tāng north of Changchenmo [pl. 6].

Todd sketched the detail course of the Indus river, and to the south-east, "as far as the Tartars would allow him". Low surveyed the Astor valley to the west during 1862 but was forbidden to cross the Indus, the Māharāja firmly refusing to let any surveyor visit Gilgit.

Montgomerie reported 7530 sq. miles of $\frac{1}{4}$-inch survey completed during 1863.

Only about 4000 sq. miles have been left unfinished, all to the north-east corner of Ladak. With this exception the whole of the materials are now available. The ground sketched ...embraced the whole of the Pangong Lake, including the eastern portion of it in Chinese Tartary; ... the course of the River Indus...[and] up to, and slightly beyond, the Chinese boundary ; the Tartars unfortunately prevented all further progress up the river [239][1].

In 1864 Johnson returned to Ladākh with Clarke and Low to finish off the distant patches with rough sketch work.

They had considerable difficulty in crossing the Himalayas ; ... by the Zoji La no less than 19 miles of snow had to be traversed. ... [Travelling up the Shyok] Mr. Johnson pushed on to the Changchenmo valley. ... A great part of the plains...were still covered with snow, even at the end of July. ...

From Changchenmo he advanced first in a northerly direction [to the western limits of the Lingzi plains]; then returning in a south-westerly direction...he approached nearly to the [upper] Shyok River, but finding that there was no path of any kind along that river, he marched right over the mountains till he struck upon the Yarkund road. ...

He marched on to the Karakoram Pass and descended three marches into Eastern Turkistan; ... he returned to Leh and thence to Kashmir. ... Mr. Clarke advanced towards the Karakoram by the Nubra with supplies which proved very useful, ... but his services were not required for sketching as the whole of the ground had been surveyed...[by] Mr. Johnson. Mr. Low had great difficulty in proceeding up the Shayok River and...sketching...in the Changchenmo and Shayok vallies[2].

In November 1864, Montgomerie reported the completion of all survey "of the dominions of H.H. the Maharaja of Jummoo and Kashmir" as far as is "at present accessible to Europeans", and two months later he applied for furlough[3]. His great task had been completed, and he had been continuously on duty for thirteen years. He asked that Johnson might be given one last opportunity ;

A great many more points ought to be fixed...east of the Pangong Lake. ... An area of about...16,000 square miles might be sketched without interruption. ... Mr. Johnson might be able to extend the triangulation with an 8-inch instrument, and even without getting on to the range south of Khotan he might be able to fix more points to the east[4].

Permission was granted and Johnson left Dehra Dūn on 1st May 1865, and reached Leh on 17th July via Simla and Rāmpur. Here he received an invitation from the "Khan Badshah" of Khotān to visit his capital, Ilchi, which would take him across the frontier in breach of standing orders. There was no time to obtain permission from India, but he was not the man to miss an opportunity.

He crossed the Kuenlun by the Yangi Pass, climbing three of the peaks fixed by his triangulation of 1862 and sketching a wide area beyond. Unfortunately his board had been wrongly plotted so that his work was out of position and had to

[1] *GR Trig. 1862–3* (3–5), JTW., 1–9–63; *1863–64* (2–3), DOR. 1–11–64; *GTS. Syn.*, VII (XXXV–vii—C); *JRGS.*, 37, 1867 (343–63); DDn. 53 (303), 24–3–62. [2] DDn. 51 (119), TOM. to STS 2–12–64; *GR Trig. 1863–64* (14–5); *GTS. Syn.*, VII (XXXVII–ix—C); Wood's criticism of Johnson's Karakoram work, *SI., Records* VIII, A (28–35). [3] DDn. 51 (117), 7–11–64. [4] ib. (125), 16–1–65.

be rectified on his return to Dehra[1]. He worked across the mountains till he was met by a deputation from Khotān and conducted to Ilchi, which he reached on 17th September. Receiving a warm welcome, he stayed there about two weeks, making several excursions to the east. He then returned westward through Sanju and Shahidulla, climbing several peaks and sketching as he went. He crossed the Karakoram Pass from the north, height 18,270, to reach Leh on 1st December[2].

Though welcomed for its geographical value, this remarkable journey brought an official rebuke which contributed to Johnson's resignation and acceptance of a post in the Māhārāja's service on three times his survey salary.

In 1865 the Kashmir party moved to the survey of Kumaun and Garhwāl[3].

MAPS & MEMOIRS

Many maps and memoirs were prepared from Montgomerie's Kashmir survey.

The ½-inch *Map of Kashmir with part of Adjacent Mountains* was drawn in four sections at Dehra Dūn and despatched to Calcutta in May 1859[4]. It stretches from meridian 74° on the west to 75° 40′ on the east, and southwards to the British border. On the north-east it covers the Lolab valley and then follows the range through Hant and Haramukh to the Zoji La. It bears a note on its construction ;

Heights of trigonometrical stations...depend on the provisional height of Banog Observatory...7,454 feet [21, 66]. Heights of passes...chiefly...from comparative observations with barometers and boiling point thermometers [69, 236].

Glaciers and beds of perpetual snow...in emerald green. ... Compiled by W. H. Scott, Chief Draftsman ; ... drawing and printing by Sheik Golam Kadar.

[Roads, red—Rivers, blue—Hill shading, vertical hachures—"Clay cliffs" in Jammu area, burnt sienna—Names of special interest include :—Srinagar or Kashmir—Mahadeo or Boorzwas, 13,087 ft.—Gwashbrari or Kolahoi, 17,839 [pl. 13]—Ambernath Cave].

In acknowledging its receipt Thuillier said that he intended to take it himself to the Governor General's Military Secretary, and should His Excellency desire to see the map, I hope to...lay it before him and point out its merits. ... All the beauties of such an elaborate and highly finished production are not to be appreciated by a single inspection[5] [319].

The Governor General expressed his appreciation that this work...should have advanced so steadily whilst all India has been distracted by war and tumult, and...that in such a time Captain Montgomerie should have succeeded...in retaining the loyal and willing service of the natives of Hindostan who have been under his command, and in showing...that the causes which have disturbed the Government of India in almost every other branch have had no effect in checking...this great task [485][6].

The Secretary of State passed the map to the Royal Geographical Society where it was exhibited at a meeting of 12th December 1859[7] at which both Everest and Vigne were present. It then went to John Walker to be lithographed during 1861[8]. On the copies reaching Calcutta, Montgomerie asked for one to be prepared *in grand style* on rollers for the Maharaja, and two copies to fold up in the shape of books, with a red cover and gilt Royal Arms for his use. I will then be able to present them to him when I reach Jamoo. I think it will make him *razee* [satisfied], as from the great delay he must have begun to think that I had no intention of giving him any[9].

Reprints made at Calcutta in 1877, and again in 1904, lose, of course, all the beauty of the original manuscript and of Walker's first lithographs[10].

This lithographed ½-inch map carried as inset Montgomerie's *Kashmir Route Map*, scale 32 miles to an inch, which had been first lithographed at the Surveyor General's Office, Calcutta, 1859-60 [pl. 13]. Thuillier was shocked to find that the Punjab Government, after receiving 25 complimentary copies, had this route-

[1] DDn. 93 (256-7, 266), STS. to Home Dept. 3/24–1–67 ; Kenneth Mason. [2] *GTS. Syn.*, VII (XXXIX-XLIII—C) ; *JRGS.* 37, 1867 (with 1–47) ; map, *IO Cat.* (257) *NF Atlas* (13). [3] Markham (132–3) ; *GTS.*, I (16–7). [4] submitted by TGM., 20–4–and by SG., 26–5–59 ; ms. copy, MRIO., 48–O–57 ; *IO Cat.* (256) ; *JASB.* XXIX (20-35). [5] DDn. 668 (109), 16–6–59. [6] DDn. 649 (157), Mil. Dept. to SG., 19–7–59. [7] *RGS Progs.* IV, 1860 (29-32), with copy of GG's letter of 25–9–59. [8] *IO Cat.* (256) ; price 12 sh., J. & C. Walker. [9] DDn. 46 (88), TOM. to STS., 30–1–62. [10] photo-zinco., SGO., Dec. 1877 ; helio-z. SGO., No. 586, SI. Sept. 1904.

SRINAGAR

Reduced from two-inch survey made by Alexander Melville and Edward Ryall during May and June 1859, after William Beverley had fixed the extra trigonometrical points.

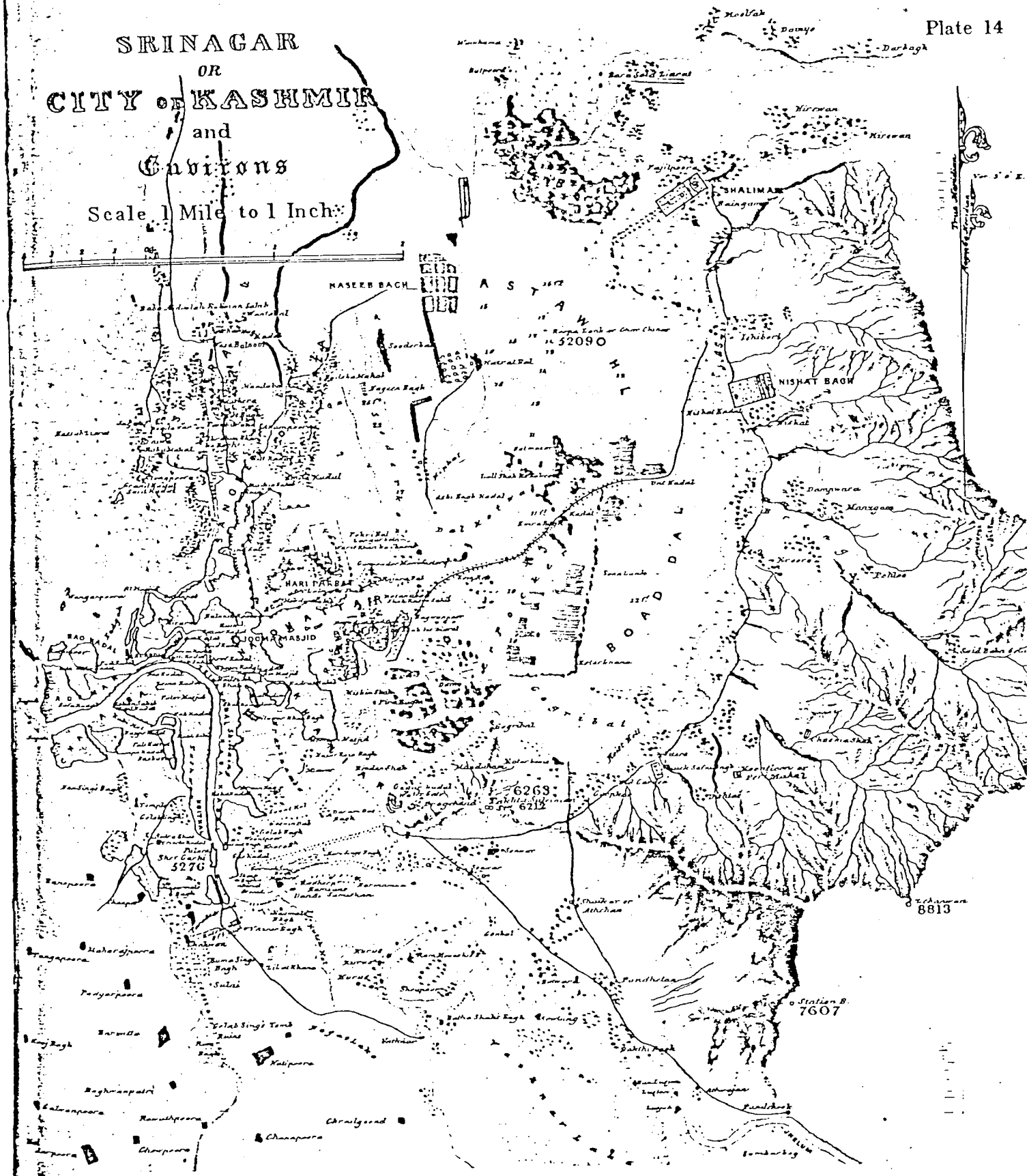
The full-scale map was fair drawn in Dehra Dūn—the hills by James Peyton, the lettering by Sheikh Ghulam Khadar—and photo-zincographed later.

A reduction made to the one-inch scale "chiefly by Lieutenant Melville" appeared as inset to the large ¼-inch map of Jamoo, Kashmir, and Adjacent Districts, that was lithographed in London in 1861. This reproduction is made direct from the inset on the ms. copy (GBO. Lib. D–4).

As in all great cities the built-up area has changed out of all recognition during the past 100 years.

SRINAGAR
OR
CITY of KASHMIR
and
Environs

Scale 1 Mile to 1 Inch



See notes on reverse.

W. Wheeler Lt.
Topog. Asst.
5-11

map reprinted locally for issue to officers going on leave. He assured them that he could send them as many copies as they wanted from Calcutta[1].

A separate map of *Dominions of H.H. Runbir Singh, ... Jamoo Territories,* also on the ½-inch scale, was drawn at Dehra Dūn in 1865, and lithographed in three sheets at Calcutta in 1871. This stretches from the Jhelum on the west to Sachi Peak in Chamba on the east and to the Pīr Panjāl on the north[2].

The ¼-inch map entitled *Jamoo, Kashmir, & Adjacent Districts* stretches from the Jhelum River on the west to meridian 76° 30′ to overlap the Chamba survey. To the north it follows the western and northern watersheds of the Kishanganga, excluding Nanga Parbat ; then the great range eastward to the Zoji La and Nun Kun, and then south by Brāma [230 n.3][3]. The original map in four sheets left Dehra Dūn with the Surveyor General in January 1861, together with a triangulation chart ;

> The previous map contained only Kashmir proper. ... The work now submitted is a general map...comprising the whole mountain tract from the plains of the Punjab on the south up to [Little] Tibet, or Baltistan, and the glaciers of Nanga Parbat on the north. ...
>
> For the early completion of this beautiful map and chart I am mainly indebted to...Mr. Wm. Scott, who has been unremittingly employed on this work from sunrise to sunset for the last 9 months. ... Hill shading, to Mr. James Peyton. ... Golam Kadar and Kullummooddeen have also been assiduously employed...in printing.
>
> The next instalment of this survey will include Little Tibet, Baltistan, the whole of the field work of which, and of the country as far as Le, has been lodged in my field office, and its compilation will be immediately taken in hand[4].

Whilst Waugh presented this first copy at the India Office in person he left a second in progress at Dehra[5], where it was lithographed in May 1862. Photographs from the field sections sent for compilation at Calcutta were not satisfactory. 800 copies were lithographed in 1863 by John Walker in London [319], including as inset a coloured 1-inch reduction of the Srinagar city map [*inf.*][6].

Pending appearance in the Indian Atlas the eastern part of the Baltistān-Ladākh survey was published at Dehra Dūn in 1868 on the 8-mile scale, in 14 sections, under title *Dominions of Maharajah of Kashmir*[7]. These sections with their covering index show a continuous boundary line enclosing the Māhārāja's dominions. As determined by the surveyors of 1862 to 1865, this followed the crest of the Kuenlun Range and cut the Pangong Lake on its southward run to Hanle [237, pl. 5].

The full survey was incorporated into Atlas sheets published between 1867 and 1875, and beautifully engraved they were [pl. 13].

Other maps and memoirs include ;

Panoramic View of the Kashmir Mountains. Montgomerie, 1857. Scale 3 degrees to inch In two sections, coloured. Printed in tinted lithography, S.G.O., Calcutta, 1859 [230 ; pl. 15][8].

> A drawing on stone having proved unsuccessful Thuillier engaged a superior artist in Calcutta, Mr. H. Frazer, who has made a successful copy [on the stone] ...which we have lettered and printed in tinto-lithography in the office. ... 50 copies have been struck off. ... The charge made by Mr. Frazer for the drawing is 250 rupees[9].

The two-inch map of *Srinagar or City of Kashmir,* was printed in black and white at Calcutta in September 1863, two copies in book-form being "handsomely bound in velvet for presentation to the Maharaja" [232 ; pl. 14][10].

A set of 32 *triangulation charts,* with an index [pl. 6] of the Kashmir and North-West Himālaya series is contained in *Synoptical Volume,* No. VII, 1879[11].

Memorandum on Central Asia, dated 13-7-1861, with a map of all the countries from the Black Sea nearly to Nankin, with report on possibilities of trade and commerce[12].

Kashmir Routes[13]. 1st edn. ; 63 routes, 1872 ; 2nd. edn., 88 routes, 1883.

---

[1] *IO Cat.* (256–7), 5th edn., 1864 ; DDn. 6 (53, 100, 178), SG. to & from Punjab Govt. 11-7-61 to 20-1-62. [2] MS. MBIO. Misc., 71-O-60 ; *IO Cat.* (257) ; price 8 sh. the set. [3] MBIO. Misc. 62 & 73-O-60 ; *IO Cat.* (256–7). [4] DDn. 533 (12–18), SG. to Mil. Dept., 25-1-61. [5] GBO. Lib., D (4). [6] DDn. SSI. to G.G. (Mil.), 31-10-61. [7] covers area 32° to 36° 25′ N. by 77° 15′ to 10° 30′ E. ; price 20 sh. the set ; *IO Cat.* (257) ; DDn. 7 (213), STS. to SG., 31-3-68 ; DDn. 100, STS. to DSG. Calcutta, 26-11-68 ; DDn. 102 (158), SG. to STS. 28-4-70. [8] MBIO Misc., 52-O-57. [9] DDn. 668 (106), DSG. to SG., 14-6-59 ; DDn. 52 (171), SG. to TOM. 7-12-61. [10] DDn. 7 (147–8), STS. to SG., 14-5-63. [11] *IO Cat.* (45–6) ; 10 preliminary charts and index pub. 1872. [12] DDn. 51 (71) ; *GTS. Syn.,* VII (xlvi-1—C). [13] *IO Cat.* (257), route book 24 pp., 1872 ; DDn. 53 A (18–9), routes to Gilgit via Skardo & Astor ; Mason's *Routes* 1st edn. 1923.

LITTLE TIBET

Throughout his ten years in Kashmir Montgomerie used the name Little Tibet as equivalent to Baltistān both in his maps and reports [147, 232; pl. 13]. He obviously found it in general use and fully established, for he never discusses or questions its origin or significance. This name is not of local origin but had been applied to Baltistān as early as the 15th century and was shown on Rennell's maps of 1793. The word Tibet comes from the Arabs and was used in the form TI-BAT by Abu Zaid and Ibn Haukal in the 10th century [1: pl. 4] as a geographical term for the highlands stretching roughly from Gilgit to China[1]. In 1835 Vigne found that all the muslim districts from Hunza to the east were known to the ruling classes as Little Tibets or *tibat-khurd*[2].

From time immemorial Balti, or Little Tibet, capital Skardo, *Lukh Butun* to Kashmiris, *Balti-yul* to Baltis and Ladākhis, *Po-lu-lo* to Dards, and *Po-lo* to Chinese, has been politically distinct from Ladākh, Great or west Tibet, capital Leh. Kashmiri *Bud Butun*, whilst both were distinct from modern Tibet, capital Lhāsa, known locally and to the Chinese as *Ur-tsang* or *Bhota* [1: 67].

The people and language of Balti are both of Mongolian origin though now much changed, except in remote villages on Ladākh border, by Aryan infiltration from Gilgit and the west. The Baltis had been converted to the muslim faith during the 16th century, and during Aurangzeb's reign, 1658-1707, came under the influence of the Mughal Empire.

Of the following authorities those named in capitals had personal local knowledge and those with asterisk are the more trustworthy :—

*SHIVARA of Kashmir, III (445), c. 1475; v. Grierson (32); Stein (134).

MIRZA MUHD. HAIDAR, 1540[3]; auth. *Tarikh-i-Rashidi*, tr. Denison Ross, ed. Ney Elias (136n., 407-10).

Abu-l-Fazl, auth. *Ain-i-Akbari* [1: 113 n.3], c. 1580; tr. and ed. Gladwin, II (152), and Jarrett & Sarkar, III (7); quoted by Rennell (136).

*DESIDERI, 1715 [1: 68-9]; v. *Lettres Édifiantes*, V (184-8), tr. by Markham (appx. 302-8); v. Rennell (97) and De Filippi (74-117) [1: 71-2]. Father Desideri travelled through Baltistān, 1715, on road to Lhāsa. Describes Tibet as consisting of three distinct kingdoms—lesser Tibet or Baltistān—Great Tibet or *Lhatayul* [Ladākh]—a third Tibet, so called by Europeans and Persians, but called *Butaut* by Indians and Mongolians, and *Po* or *Urtzang* locally. Considered Baltis to be of same race as those of countries to the east; their language was similar, but they had become Muslim.

Delisle, Guillaume, map of Central Asia, 1706 [1: 67, 209].

Tieffenthaler, *Description...de l'Inde*, Paris, 1791, Kashmir section.

*Rennell, *Memoir* 1793 (97, 136); Maps — *Hindoostan—Countries...between Delhi & Kandahar—Countries between Indus...& Caspian* [1: 214; pl. 8].

Remusat, auth. *Recherches sur les langues Tartares*, Paris, 1820.

HENDERSON, c. 1835 [IV, 290]. ABDUL RAHIM, 1833-4 [IV, 290-1]. VIGNE, 1835, II (248-53) [IV, 472].

CUNNINGHAM, 1846-7, auth. *Ladak* (27-37, 261), with map by John Walker 1854.

STRACHEY, Henry 1847. THOMSON, 1847 (247).

*MONTGOMERIE, 1855-64, official reports & maps [147, 232, 236; pl. 13].

DREW, 1862-72 (238, 256-80). Balfour, I (311); V (110-1). Yule; 1866 edn., I (lxx n.); 1915 edn. (71n.).

GODWIN-AUSTEN, 1860-3; *Vocabulary Balti-Kashmiri* (233-40).

LEITNER, 1875; *Languages & Races of Dardistan* (2). KNIGHT, 1891 (230-1, 247).

*FRANCKE, 1890-1910; auth. *History of W. Tibet* (16-7), and with Grierson, III, part I (14, 32).

*STEIN, 1888-96 (131-2). *ARTHUR NEVE, 1903 (75-84). ERNEST NEVE, 1912 (206-17; map).

Imperial Gazette, 1908, VI (261-3); sv. Baltistān. Burrard & Hayden, 1933 (15-6).

Cotton, J. S., *Ency. Islam*, I, pub. Leyden, 1913, sv. *Baltistan*.

*DAINELLI, of De Filippi's expn., 1913-4; rev. *Sc. Geo. Mag.*, XL. 6. Nov. 1924 (334-44).

MIR IZZAT ULLAH, 1812; auth. *Travels in Central Asia*; tr. P. D. Henderson, Calcutta, 1872.

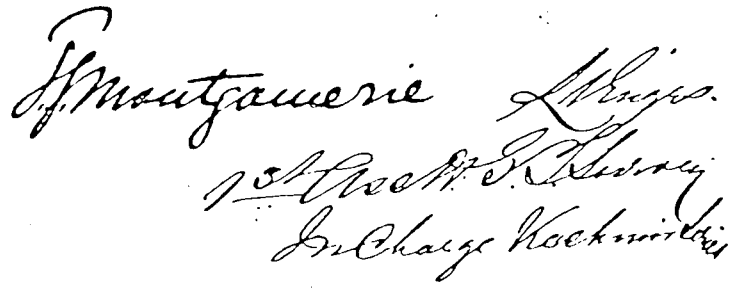
NF Atlas, pl. 14, John Arrowsmith, 1876; pl. 16, Intell. Br. Simla 1891.

[1] v. *Hobson Jobson*. [2] Leitner (103); Vigne, II (250); Ferguson (34-7). [3] *RGS Progs.* XV, 1870-1 (482-93); *JRGS.* XLVI 1876 (277-98); Mirza Haidar, prince of Kashgar, ruler of Kashmir 1541-51; auth. of geogl. account of countries N. of Kashmir.

PIR PANJAL

"Part of a Panoramic View of the Kashmir Mountains taken from the ruins of the Roostamgurhi under the TAKHT-I-SULIMAN near Srinagur. The principal points fixed by a theodolite."

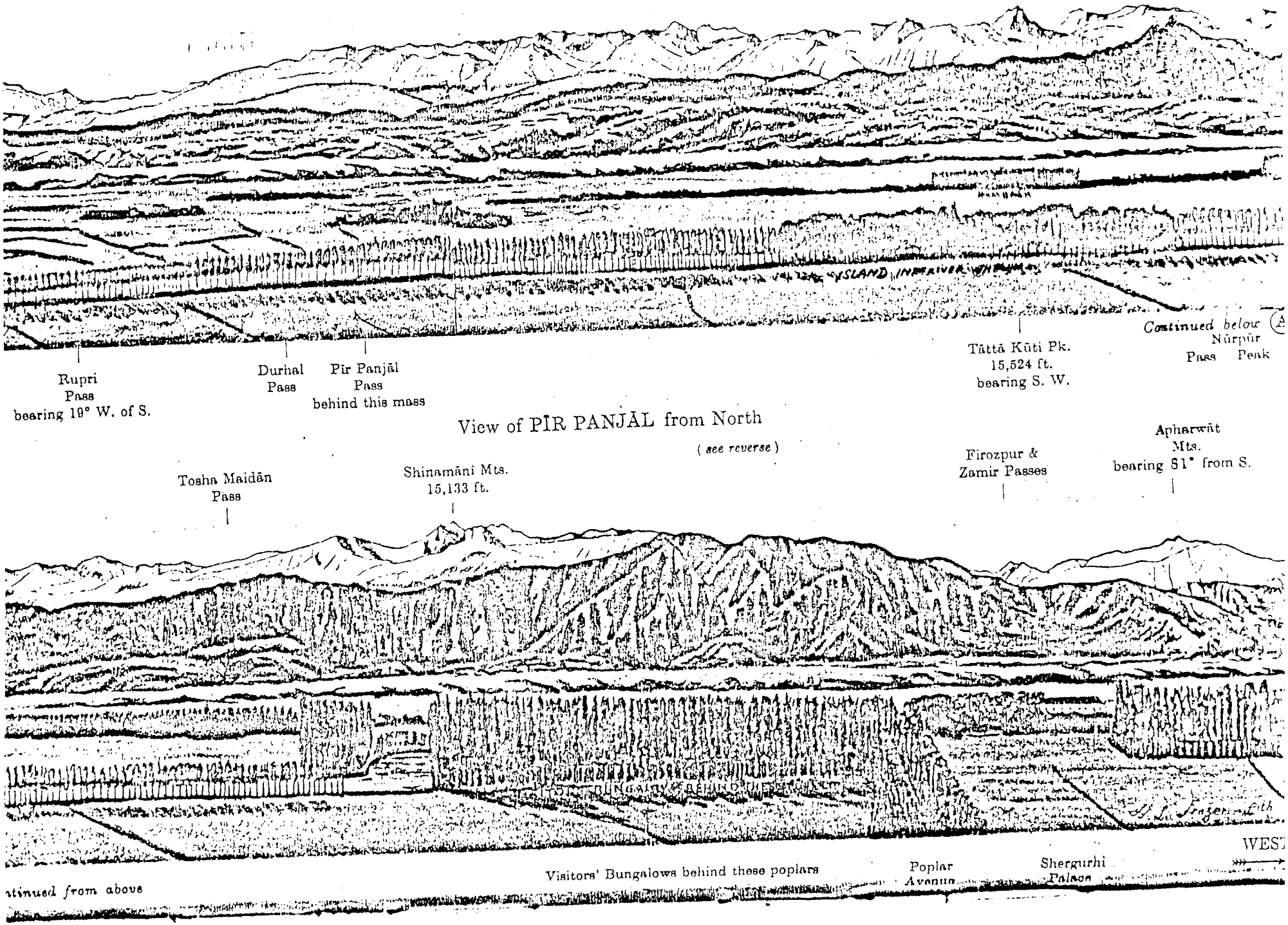
"Sketched in October 1857 by T. G. Montgomerie, Bengal Engineers, to illustrate the G.T. Survey Map of Kashmir. Scale 3 degrees = 1 inch".



Reproduced to full scale from part of the original sketch in sepia, with entry on left, "Drawn by T. G. MONTGOMERIE" and initialed T.G.M., which is held amongst Survey Records as MRIO. Misc. 52-O-57, and extends to a full length of 53 inches from Peak HAMUNARAG, 14,187 ft., on the east, to KAJNAG Peak on the Kagan range on the west, and including tho BANIHAL pass.

Fifty coloured litho prints were struck off by H. L. Frazer, Lithographer, of Calcutta, in 1859.

Reg. No 6064 HE '54-800'60.


Rupri Pass bearing 19° W. of S.
Durhal Pass
Pir Panjāl Pass behind this mass
Tāttā Kūti Pk. 15,524 ft. bearing S. W.
Continued below
Nūrpūr Pass
Peak
View of PIR PANJAL from North
(see reverse)
Tosha Maidān Pass
Shinamāni Mts. 15,133 ft.
Firozpur & Zamir Passes
Apharwāt Mts. bearing 81° from S.
Visitors' Bungalows behind these poplars
Poplar Avenue
Shergurhi Palace
WEST
ntinued from above

CHAPTER XVI

REVENUE SURVEYS, LOWER PROVINCES, BENGAL[1]

General Narrative — No. 1, or North Division : Purnea to Dināj̄pur — No. 2, or South Division : Midnapore, 1844–7 — Hooghly, 1844–6 — 24-Parganas, 1846–52 — Calcutta Suburbs, 1846–52 — Nadia & Burdwān, 1852–60 — No. 3, or East Division : Sāran & Tirhut, 1843–9 — Mymensingh & Dacca, 1850–60 — No. 4, or West Division : Shāhābād to Bākarganj — Revision of Boundaries.

IN 1844 the revenue surveys still in progress in the Bengal Presidency were those of Gaya, Sāran, and Purnea in Bihār—Midnapore—and Assam, all under control of the Sadr Board of Revenue at Fort William. Bedford had vacated the post of Deputy Surveyor General and Superintendent of Revenue Surveys in January 1843, and Wroughton succeeded in February 1844 [IV, 323 ; V, 348][2].

At the end of season 1843–4 Walter Sherwill, having completed survey of Bihār, or Gaya, District, took up that of Shāhābād to the west, sending a detachment into Monghyr the following season. Maps and returns for Shāhābād were submitted by the end of 1846, those for Monghyr the following year, and start was made in Bhāgalpur during 1847. Samuel Tickell then held charge whilst Sherwill was on furlough, but he had no previous experience of revenue survey and much of his work had to be resurveyed [255]. From Bhāgalpur Sherwill moved eastward into Birbhum and then to Murshidābād. Early in 1854, he handed over to James Gastrell, to take up duty as Boundary Commissioner [243, 255–7, 397].

Maxwell had reverted to military duty after moving his party from Patna to Sāran District, and in February 1844 charge was given to Alexander Wyatt who had served as assistant before the retrenchments of 1842 [IV, 387–8, 398]. Having completed Sāran and "Sircar Chumparun", Wyatt moved east to survey Tirhut, or Muzaffarpur, which he completed by the end of season 1848–9, after surveying the newly revised boundary with Nepāl[3] [IV, 460]. During 1849–50, the party was transferred to Mymensingh in East Bengal, a very difficult country cut up by waterways and extending into the wooded foothills of the Garo Hills ; survey was not completed till 1857, in which year Wyatt died whilst on sick leave [254, 434].

In 1845 John Fitzpatrick who had held charge of survey in Purnea since 1841 [IV, 184] was relieved by Pemberton, senior assistant from Sherwill's party [pl. 25]. By the end of season 1846–7, Pemberton had completed the area remaining in Purnea, as well as that part of Bhāgalpur lying north of the Ganges, and started in Mālda to the east. By 1855 he had completed survey of districts Mālda, Rājshāhi, and Bogra, and he started that of Rangpur in North Bengal from season 1855–6.

In Midnapore, after Mathison's departure in 1844 [IV, 191], serious discrepancies were found between the *khasrah* and the professional survey, and for the next three years a detachment was employed in revising the faulty work, whilst the main party under Wilson completed the survey of Hooghly and made a start in the 24-Parganas. In 1847 Major Smyth took over charge on return from furlough, and on his reports the whole of Wilson's work in those two districts was rejected [247, 299]. Whilst surveying the 24-Parganas Smyth completed the large-scale survey of landed property in the suburban area of Pānchannogrām that had been started by Michael Crow in 1841 [IV, 192 ; V, 249–50], and also revised the Sundarbans boundary [248–9]. In 1852 he took up the survey of Nadia [250–1].

[1] Index Map 1848, 32 m. to inch, MRIO. Misc. ; Hirst, descriptive account with Glossary. [2] *GR. Rev. 1876–7 : Appx. I ;* List of Rev. Svys. 1845–87, Burma to Sind. [3] DLR. 36/27 (184), 1849.

From about 1844 responsibility for the surveys and assessments was transferred from the Commissioners of Divisions and Collectors of Districts to special Superintendents of Survey, working under a Controller responsible to the Board of Revenue [244, 247]. These Superintendents had Deputy Collectors for settlement and demarcation of boundaries ahead of the professional survey, and were themselves responsible for priority for areas of survey, and their satisfactory completion for assessment purposes. The detailed field, or *khasrah*, survey by *amins*—only required in special areas [IV, 179 ; V, 244]—had long been managed by the professional surveyor in addition to his survey of boundaries and topographical detail.

It was not always easy to preserve close co-operation between the civil Superintendent and the Surveyor. Demarcation of boundaries was often delayed, and the boundary details, or *thakbasts*, supplied by the revenue officers were often faulty and unintelligible. On the other hand the Superintendent's staff frequently complained of faults found in the *khasrah* survey at the time of detailed classification and assessment. In 1850, as a result of serious discordancies in Midnapore and Hooghly it was decided to transfer the *khasrah* survey entirely to the civil side.

In 1851 the surveys were re-arranged by Divisions instead of by districts ;

> The present mode of designating the Surveys and Superintendencies by Districts is...liable to objection. Frequently...the Superintendents are designated from districts the survey of which has been long since completed. ... It would...be more convenient...to class both the Survey and the Superintendencies by numbers, and with reference to the part of the country in which the operations are carried on. ...
>
> 1st., or North, Division, to include the party now under Mr. A. R. Young as Superintendent and Mr. Pemberton as Surveyor, at work in Rajshahye.
>
> 2nd., or South, Division, to include the party now under Mr. H. M. Reid as Superintendent and Capt. Smyth as Surveyor, in the 24-Pergunnahs.
>
> 3rd., or East, Division, to include the party now under Mr. Bell as Superintendent and Mr. Wyatt as Surveyor, in Mymensingh.
>
> 4th., or West, Division, to include the party now under Mr. A. Money as Superintendent and Captain Sherwill as Surveyor, in Beerbhoom[1].

Besides these regular parties there were other local surveys. John Thornton, now an Assistant Commissioner in Upper Assam, continued till 1846 in charge of local surveys which included a revision of the Matak tea area [IV, 204–5]. Charles Mullins was employed from 1841 by the Commissioner of the Sundarbans on survey of new grants and reclamations along the Sundarbans border [IV, 194 ; V, 248–9].

In 1847 the Commissioner of Chittagong asked for an 8-inch survey of the island of "Shahbazpoor[2]" lying in the Meghna River, forming part of the district of Noākhāli or Bhulua. John Kelso [IV, 399] was specially re-employed, and completed this survey during season 1847–8. He then took over the survey of Goālpāra District in Lower Assam on which James Bedford had been working in 1842 [IV, 202–3]. This had been resumed by John Swiney in 1847, and on his death in 1848 by S. Phillips who stayed on a few months under Kelso. Kelso held it as Division No. 5 till the end of 1853, when he was relieved by James O'Donel who closed down the survey in December 1854[3].

In 1853 the professional staff of the four regular divisions comprised four Surveyors in charge—one military assistant under training—20 European, Anglo-Indian, or Indian assistants—and 90 Indian surveyors. The boundary demarcation and *khasrah* staff under the Civil Superintendents cost on the average Rs. 60,000 for each division, whilst the cost of the professional survey establishment averaged Rs. 30,000[4]. In 1854 establishments were raised to double strength as had been done in 1837 for the parties of the North-Western Provinces, and at which strength the two parties had been transferred to Bihār at the end of 1841 [IV, 216–8, 392]. This increase was effected gradually as trained staff became available

[1] DDn. 562 (146), Rev. Bd. LP. to Rev. Dept., 11–6–51 ; B to CD., Rev., 18–8–52 (45). [2] BBC. 25–8–47 (17–20) ; from Comnr. 24–6–47 ; from DSG., 12–7–47 ; maps, DLR. 37/77 (1) ; MRIO. 39 (5) [pl. 17]. [3] Hirst & Smart (3–10, 11–30) ; Kelso's corr., DLR. 37/77–80 ; *GR. Rev.* LP. (51–2) ; maps by O'Donel, MRIO. 34 (43) ; DLR. 37/80 (155, 247) ; Goālpara Dist., 1849–54, *IO Cat.* (198, 301). [4] *GR Rev. 1851–2* ; from Rev. Bd., 19–7–53.

Some of the changes in administrative procedure introduced by order of the Board of Revenue were by no means welcome to the surveyors [294, 300].

Many improvements in professional procedure were introduced through the initiative of either Henry Thuillier who was Deputy Surveyor General from 1847 or of Ralph Smyth, who collaborated in producing the important handbook, *The Manual of Surveying for India* [283–4]. One of Smyth's more valuable innovations was the arranging of traverse circuits in "convenient and compact blocks, or main circuits, containing a specified number of congregated villages, without attempting to run after the pergunnah limits in the field" [298, 305–6]. The *parganas* of these districts were indeed most difficult to survey as separate units, being broken up and intermixed, and having "innumerable outlying villages lying widely apart"[1].

It was on this account that at the end of 1853 the Government of Bengal "determined to recast the whole of the Jurisdictions...to form compact and regular police divisions, in place of the confused and intermixed fiscal pergunnahs"[2]. Walter Sherwill was placed on special duty for this purpose as Boundary Commissioner, commencing at Patna in January 1854. By 1860 when he retired he had readjusted the boundaries of all the Bihār and most of the Bengal districts, their subdivisions and thanas, with suitable headquarters and communications [256–7].

Between 1855 and 1860, No. 1 Division, continuing north of the Ganges, surveyed the large district of Rangpur with the State of Cooch-Behār and the northern part of Dinājpur. Pemberton died in April 1860, and was succeeded by Robert Smart who moved the party east to Tippera at the end of that year.

After completing Nadia District—"the garden of Bengal"—Smyth took up the survey of Burdwān with No. 2 Division in season 1855–6. As an experiment he combined the charges of Civil Superintendent and professional Surveyor, and managed the two establishments with such success that his party completed a record area at greatly reduced cost rate. Government, however, preferred not to persist with this system as normal procedure [250–1, 301]. In July 1857, his health having suffered severely from long service in Lower Bengal, Smyth took furlough preparatory to retirement. A very great loss to the Department.

William Row then moved the party north of the Ganges for the survey of south Dinājpur, and the following year handed over to James Sherwill, a younger brother to Walter. At the close of season 1860–1, Sherwill moved to Mānbhūm District on the borders of Chota Nāgpur [244].

After Wyatt's death in 1857, No. 3 Division passed to the charge of Nicholas Davey who took three more seasons to finish off the Mymensingh border with the Garo Hills. Work was started at the same time in Dacca to the south, to make junction with Nos. 1 and 2 Divisions [253]. By the end of 1860, both Mymensingh and Dacca districts were completed, and Davey moved westward into Sylhet.

In February 1854, Sherwill handed over charge of No. 4 Division to Gastrell who completed Murshidābād and then moved eastward through the water-soaked districts of Jessore, Khulna, Farīdpur, and Bākarganj to reach the Meghna River during season 1860–1. 'Bākarganj was not completed till the end of 1862–3.

From the end of 1852, a small detachment was employed at Akyab under the Deputy Commissioner to carry out an experimental survey. Like the survey of 1834–5 [IV, 197] the whole detachment suffered continuously from fever and accomplished nothing of real value, even though it came under the orders of the Deputy Surveyor General in October 1853[3]. At the end of 1855 O'Donel brought down No. 5 Division to resurvey the Akyab area, and extended survey over the whole province of Arakan during the next six seasons. Whilst the small cultivated areas were rigorously surveyed on the 4-inch scale, a rough one-inch topographical survey was sufficient for the greater area of tangled forest-clad hills. The completion of this survey was a most creditable performance ; large areas were quite uninhabited, and elsewhere the hill tribes had no previous contact with the outside world. In 1861 O'Donel moved his party into the Chittagong Hill Tracts.

[1] *GR Rev. 1854–5* (appx. 1). [2] DDn. 624 (24), DSG. to SG., 5–4–56. [3] *GR Rev.* 1854–5 (52).

Whilst this Arakan survey enjoyed Thullier's close control, he could hardly have taken any live interest in the revenue survey of the Strait Settlements, though in 1847 the European surveyors working in Province Wellesley, Penang, Singapore, and Malacca were placed under his orders[1]. He never had anything to do, however, with the revenue surveys of Pegu, Martaban or Tennasserim[2] [194, 197–8].

Early in 1859 a full survey party was brought down from the Punjab under Hunter Thompson to take up the revenue survey of Chota Nāgpur, survey being started in March in the *parganas* of Kodarma and Kharakdhīya of north Hazāribagh. No civil officer being available, Thompson became his own Settlement Officer, and also demarcated the boundaries of the adjoining district of Mānbhūm in preparation for survey by No. 2 Division [243]. Whilst the revenue survey party took up work in the northern districts Depree's party from Orissa took up topographical survey from the south [176, 184].

No. 1, or North Division: Purnea to Dināpur

The revenue survey of Purnea District had been started in 1841 for the survey of a large *haveli* estate[3]—about one-third of the area of the whole district—"with a view to its partition for the benefit, and at the expense, of the proprietors" [IV, 184 ; 187 n.5]. After the retrenchments of 1842 it was carried on, with a small detachment also in the Rājmahāl Hills, by John Fitzpatrick till its completion in 1845, when Government ordered its extension to the rest of the district[4] ;

> Besides the very important check to litigation and...disputes, ... the main object...in the survey of the permanently settled districts...is to determine the relation of land to jumma [IV, 177–8] by the ascertainment of the areas and boundaries of mehals.
>
> The first step...is the accurate survey...of the boundaries, ... and where a mehal consists of one or more...compact villages...no more is required...than the professional boundary survey. But, if the mehal consist of part only of a village or villages, or if the lands...are intermixed with those of another village appertaining to another mehal, it is evident that the mere boundary survey is insufficient, and the deficiency is then supplied by...kusreh. ...
>
> Besides the above, the survey depicts the sites of villages and other geographical features, but the details of waste and cultivation are not measured as in the N.W.P. surveys, and as they have been in the survey of the havelee Purneah estate...with a view to the partition of the property into two equal portions. ... Recourse to khusreh measurement will not be extensively necessary in the Purneah survey. ...
>
> The Board have suggested the employment of only one Deputy Collector for the demarcation of boundaries in Purneah in place or two as in the other surveys, ... believing the estates there to be more compact than in the other districts[5].

Fitzpatrick's establishment comprised 5 sub-assistants[6]—4 *amīns* drawing from Rs. 8 to 20 a month—14 measurers or *khalāsis* at from Rs. 4 to 7—one doctor at Rs. 15—and a guard of 8 *burkandaz* at Rs. 4 each.

Being dissatisfied with Fitzpatrick's traverse circuits and calculations Wroughton obtained his discharge, and in June 1845 brought in Pemberton from Sherwill's party to take up the district survey which was "to proceed as nearly as obtainable to the practice pursued by Lieut. Sherwill on the survey of Shahabad [254]"[7]. The Board of Revenue commented in their next report on "the great improvement in the quantity of work performed, ... attributable to the supersession of Mr. Fitzpatrick by a capable and active officer, ... and by the appointment of a Superintendent to conduct the boundary demarcation [242]"[8].

During season 1845–6 the frontier between Purnea and Nepāl was surveyed in co-operation with Edward Ommanney [IV, 460 ; V, 185], and the following season a survey was made of the disputed boundary with Sikkim[9].

[1] BRC., 21–4–47 (6–8); Marriott, Prov. Wellesley; O'Hara, Penang; Thomson, Singapore. [2] DDn. 690, G of I. to Comnr. Tenasserim, 18–6–56 ; Comnr. to Ch. Comnr. Pegu, 10–6–62 ; McMahon, Pegu ; Hobday, Martaban and Amherst from 1855 ; Montgomerie, Amherst, 1860–2. [3] = lands of hdqr. town. [4] Rs. 2,253 pm., charged to Govt. from May, 1845. [5] BRC., 4–6–45 (6); from Rev. Bd. LP., 17–4–45. [6] O'Donel, A. Smith, C. Mullins, Pringle, & A. Phillips. [7] DLR. 37/51 (23), 26–6–45. [8] BRC., 21–4–47 (12) *IO Cat.* (173), 4-m. map Purnea, 1840–7. [9] BRC., 9–7–45 (16, 43) ; DLR. 36/17 (62), 1–2–47.

By the end of season 1847–8, Pemberton completed the survey of Purnea and north Bhāgalpur [241], and started that of Mālda to the east. Special care was taken to make good connection with Wyatt's survey of Tirhut and Sherwill's to the south of the Ganges; much difficulty had been found in map compilation because earlier surveyors had neglected to survey both banks of riverain boundaries [252, 262, 294]. Work was delayed by boundary disputes and by the numberless villages lying detached beyond the main district boundary. The party comprised no fewer than 125 *amins* employed on contract and, writes Pemberton,

I have had so much to do this season that up to the 15th instant I have not had one spare hour; ... for four months of the recess I have been at my desk for 15 hours daily. ... I have surveyed parts of no less than six districts during the past season [1847–8]. This has been unavoidable as the index will shew you...pergunnahs completely interlaced[1]

He kept in close contact with district authorities. He saw the Judge at Bhāgalpur about "the jheels in the vicinity of the civil station of Purneah, and which are without doubt the cause of its insalubrity at certain seasons of the year"; he gave advice about drainage and the annual clearing of watercourses[2]. Whilst in Mālda he had a large-scale survey made of the famous ruins of Gaur, which had been the capital of Bengal till 1564[3], and records that

the district having been settled in perpetuity [1 : 140 ; v, 6], the demarcated boundary of villages alone have been surveyed, with their interior geographical features. Except...where minute intermixed lands have occurred, or...villages...sub-divided, ... khusrah measurements have not been resorted to. 228 villages, ... an area of 218 square miles, have been measured by khusrah. The regular survey...was commenced in season 1847–8 and finished in...1848–49. One or two pargannas were surveyed so far back as 1840. The...operations are completely identified with the several stations of the Grand Trigonometrical Survey [295–7][4].

In Rājshāhi the tiresome intermixture of *mahāls* and *parganas* was still more pronounced, but Pemberton maintained close and friendly relations with his Civil Superintendent, and the Board of Revenue appreciated

what can be done by a good Superintendent working with a good Surveyor. Messrs. Pemberton and Shore[5] have...produced almost a professional khusreh. ... They have surveyed zemindaries though the patches were as small as one acre, and the Surveyor reports that the increased expense of his survey is *more than covered* by the decreased khusreh expenses. Thus, not only has a tedious and difficult process of khusreh measurement proved unnecessary, but the mehals are accurately recorded in the professional maps, making them infinitely more complete and valuable; in fact, finishing off in one operation what has hitherto been obtained by two[6].

During 1851 responsibility for the *khasrah* involving 2,000 villages was transferred to the Superintendent of Survey [242]. By 1853 work had advanced into Bogra District, and the Deputy Surveyor General notes that

the interior work has been well supervised and a considerable percentage partalled [303]. ... In consequence of the vast number of small tanks and sites without names, consisting of 3 or 4 houses each, you propose that...they may be left out of the pergunnah maps. If such a thing were sanctioned it might gave latitude for the omission of many other details. ... It is better to err on the right side. The pergunnah maps should shew all and everything of which the scale is susceptible, both as regards interior details and boundary inflections [305–6]. ...

Your maps of towns and civil stations on the 8-inch scale are not so good as I could wish. That of Bograh...[looks like] the imperfect sketching of a very third-rate...assistant. ... It would be far better not to give such maps at all. ... In your map of the station of Maldah and ruins of Gaur, the topography was obliged to be added...in this office before it was lithographed[7].

During season 1854–5 Pemberton took up survey of Pabna District which lay both north and south of the Ganges, and in the following season he moved into Rangpur to the north, which district, writes Thuiller,

will occupy several seasons. ... The party strength has now been increased [242–3] and large outturns may now be expected. Mr. Pemberton is a zealous and indefatigable officer whose endeavours are always most praiseworthy. His topographical maps have not always been of that order of merit which seemed to me desirable. Brought up in the old North-West school,

[1] DLR. 36/17 (115–7), 20–12–47; 36/18 (16), 4–12–48. [2] DLR. 36/18 (57), 12–4–49. [3] DLR. 37/51 (97), from DSG., 14–1–51. [4] *Maldah* (2, 6); cf. DDn. 484; MRIO. 38 (15–16), Malda, 8 m. to inch, ib. (41), Rājshāhi; *IO Cat.* (200). [5] NCS., 1840–65; son of Rev. Thos. Shore of Suffolk. [6] BRC. Rev. Bd. LP. to Rev. Dept., 10–10–50; report for 1849–50. [7] DLR. 38/3 (31–6), 24–12–53.

he was formerly more inclined to quantity than quality, and his maps partook accordingly of the haste in which they were got up. ... This is now, I am happy to say, changed [IV, 216–8, 227]. Circuits have been surveyed by the European assistants with 7-inch theodolites, ... angular and linear measurements being taken twice by independent assistants. The initial azimuths have been laid down by the Surveyor himself with a new 9-inch theodolite[1].

Rangpur was completed during season 1858–9 and Cooch Behār the following season, during which the main party had moved down to north Dinājpur, where Pemberton fell seriously ill. In March 1860 he had to retreat to Darjeeling where he died the following month. His place was taken by Robert Smart who moved the party to Tippera District for season 1860–1 [243].

No. 2, or South Division, Midnapore, 1844–7

During 1841 to 1844, his last three seasons in Midnapore, a district covered by the permanent settlement, Mathison's party was engaged in the survey of "village boundaries, with...topographical—features...such as village sites, large patches of jungle, rivers, etc.". The object was to prepare "a correct map and area of mehals. ... No new assessment is made". Such was the official ignorance of the wilder parts that it was only just before he was leaving that a whole estate hitherto marked "Jungle Mehals" was found to have been left unsurveyed.

A mehalwar survey of the newly discovered pergunnahs [Nyagaon] in this season quite impracticable. Three-fourths of the establishment (both European and native) have returned to the station in such a state of disease and debility from exposure to jungle climate that further employment—of the few that could creep there—would in all probability kill them.

There are many miles of high forest to cut through which of itself would occupy some weeks, even if the Zemindar would assist. ... I propose surveying these pergunnahs in November next. ... An already accomplished area of nearly 1,700 square miles and a crippled establishment must plead[2].

Wilson took over charge on 1st August 1844, and surveyed the 197 square miles of these "lost parganas...settled in perpetuity". He then took the party into Hooghly District whilst a detachment under John Swiney was left to revise the unsatisfactory work on the Midnapore–Balasore border, and to reconcile the *khasrah* surveys "conducted by the native Deputy Collectors" with Mathison's professional survey [IV, 191]. This revision convinced the Board of Revenue that great discredit attached to the persons who in the first instance superintended the professional survey. ... The main defect has been in the [failure]...to compare the 'mauzawar' maps prepared by the local authorities with the professional maps [263-4, 293, 304]. Had this precaution been taken it is utterly impossible that a difference...could have escaped attention. ... Mr. Ivey, the responsible officer, ... has been called upon to account for it. ...

The villages...must be resurveyed. Up to the present time the Collector has sent in 333 villages...to be reconciled, in addition to the revisions which have already taken place[3].

Swiney completed his resurvey by September 1847 and in defence of the original surveyor asked—how it was "possible for one individual to partal 50 aumeens' work extending over...20 to 30 miles, not considering the traverses and maps that he has to bring up daily of the native surveyors ? [303-4]".

I commenced this duty on the 23rd December 1844 and finally closed it on the 10th September 1847, in which time I have accomplished the measurement of 998 villages with an area of 538 square miles, situated in 27 pergunnahs, ... incurring an expenditure of Company's rupees 22,035. Revision has effected an increase in the area of nearly 12½ per cent[4].

The Deputy Surveyor General was not entirely satisfied, and pointed out that Swiney's revision of one village without revising those adjacent to it would "leave the district in a worse state than when you entered it", and the Board of Revenue commented that Swiney's corrections "would necessitate the corrections of 2 or 3,000 other villages abutting on the first, and the professional maps and plans already prepared would cease to be a faithful record of the distribution of property". They

[1] DDn. 624 (12). [2] DLR. 37/49 (15, 32), 21–3 & 6–4–44. [3] Rev. Bd. LP., 8–3–47 ; BRO., 21–4–47 (12). [4] DDn. 482 (118, 148), 4–5 & 2–10–47.

considered that it might be better to resurvey the whole district "after the surveys in progress have been completed"[1]. No resurvey of Midnapore District was, however, carried out before the first cadastral survey of 1872–8 [iv, 191].

Hooghly, 1844-6

Several months before Wilson started in Hooghly District the Collector had been authorised to have village boundaries demarcated in advance by his Deputy Collectors, but the necessary boundary maps were not ready in time, though Wilson had been particularly warned to obtain the "mouzahwar maps" or *thakbast nagshahs* for comparison with his professional survey. "Every professional survey map shall bear note attested by your signature that it has been compared with the...hadbast map". Between February and May 1846, he had surveyed only 125 square miles in nine *parganas* by *khasrah* survey. The remainder was left till a Civil Superintendent could be appointed [242].

The new Superintendent took over duty from the Collector from 15th July 1846, two months after the completion of the professional survey, "the entire district of Hooghly, 2,233½ square miles, having been chained in two seasons, at the modest cost of 6 pie per acre"[2]. The rapidity of Wilson's survey was unfortunate, for when pursuing the *khasrah* survey later the Superintendent found that the village boundaries shown by the professional survey differed widely from those laid down in the *thakbast* maps supplied by the civil staff. Neat and accurate though the professional maps were, he had

not yet been able to compile from them the registers of a single pergunnah in Hooghly. They are accurate as far as...the professional tests...can apply but I fear they are in many instances inaccurate as regards the localities of the village. ... They are frequently at variance with the thakbast demarcations, and I have endless labour now in...reconciling them. ...

The reasons assigned by the surveyors...is that they found the thukbast incorrect, and considered themselves bound to adopt what they found to be the true state of the locality. But the Deputy Collectors maintain that their thakbust is correct, and the Surveyors' plan wrong. At any rate the Surveyor should have compared his plans with the thakbusts. ... This he has not done, and the labour of comparison...is thrown on this office...when it is too late to rectify what may be inaccurate[3] [294, 299].

When Smyth returned from furlough and took over charge he agreed that Wilson was greatly to blame. He attributed the arrears and faulty results to

incorrect and incomplete demarcation papers supplied by the Civil authorities, and neglect on the part of the Surveyor in not more urgently protesting against such documents—...want of proper supervision over the khusreh...—general want of energy and activity in permitting the work to fall into arrears. ...

Although apparently nothing can be worse than the state of the demarcation records and their entire worthlessness as a guide to a surveyor, still, ... the defects in the survey would not have been so glaring...had an experienced officer been conducting the operations. ... The very absurdity of the thakbust document as exhibited...being sufficient to attract the notice of any surveyor of the smallest experience.

The Deputy Surveyor General agreed and the Controller of Survey noted that

the thakbusts were all...*andazee* [sketchy] and...very incorrect. ... The Revenue Surveyor did not consult them, but surveyed such boundaries as were pointed out to him by villagers and others. ... In some instances he fell into the mistake of surveying as distinct villages only *paras*...which by the thakbust had been properly delineated as...one and the same village[4].

The surveyors had indeed even failed to consult the *misls* or descriptive accounts of the boundaries as marked out on the ground by the bamboo *thaks*. The Board of Revenue decided that a new survey would be necessary after the current programme had been completed[5], and this was carried out between 1869 and 1872.

During 1845, Wilson was directed to survey the foreign settlements of Chandernagore and Serampore, in topographical detail only with no attempt to investigate

[1] DDn. 562 (146), Rev. Bd. to Rev. Dept., 11-7-51. [2] DLR. 36/39 (237) Wilson to DSG., 10-12-46. [3] BRC. 27-4-47 (31), from Supt. Rev. Svy., 13-1-47 ; *IO Cal.* (176), Hooghly Dist., 1844-6. [4] BRC. 15-12-47 (28), from DSG., 14-5-47, DLR. *GR Rev.* (10), from Rev. Bd., 21-4-57. [5] BRC. 15-12-47 (36).

the value or extent of private property[1]. The external boundaries were to be laid down, and the French authorities asked that the Chandernagore limits should be re-traced on the ground; "By the treaty of January 1873 it was agreed that the limits...should be marked out by ditches. These were accordingly dug and traces of them are everywhere perceptible, though partly effaced in some places"[2]. Adjustments in the line, as demarcated by a line of pegs laid down by Commissioners, were surveyed by William Davey in April 1852[3].

The Danish settlements at Serampore were handed over to the British during the course of Wilson's survey [1 : 359 n.6].

24-PARGANAS, 1846-52

After Smyth had taken over charge[4] he rejected as thoroughly unreliable much of the *khasrah* and professional work carried out in the 24-Parganas under Wilson. He pressed for the supply of carefully prepared *thakbast* maps

as early as 1st October [1847], ... but in January had only 96 for four working parties. Slow receipt...caused much delay and confusion. ... The thakbasts supplied were of a very indifferent nature, the nukshahs being made out without any reference to the shape of the village, in many places the boundary running the very reverse of what it actually did in the field.

With much difficulty I have been able to compare 1,289 villages out of 1,462 surveyed, the remainder, 179, will require re-examination in the field. Of these I have little doubt but that the surveyed boundary is correct.

Owing to the loss of Mr. Otto by death, one of my best assistants, in the middle of February, I was obliged to take up Mr. Otto's work myself, ... otherwise the pergunnah main circuit... would have been left unfinished. The country surveyed [1847-8] has extended north and south from about 60 miles from above Barrackpore down to...below Diamond Harbour; east and west about 20 miles. The area remaining to be surveyed...is at present unknown, for the boundary of the district itself is as yet undecided[5].

The work of the Deputy Collectors was straightened out, and Smyth reported in 1850 that the *thakbasts* now supplied were everything that could be wished for

and a great improvement on the old system. With...these thakbusts I have been enabled to compare every turn and bend of a boundary, and any discrepancy...is at once brought to light[6].

Amongst the difficulties experienced during season 1849-50 were the receipt of boundary particulars from all parts of the district instead of in compact blocks, and the frequency with which the Superintendent was changed, each new officer having to learn his duties from the start and often introducing unwelcome innovations [271]. These troubles were avoided when in 1855 Smyth was given the office of Superintendent in addition to that of Surveyor [243, 301].

In addition to the district survey Smyth carried out a topographical survey of the Sundarbans boundary and completed the large-scale property survey of the suburbs [249-50]. For the Sundarbans boundary he had to lay down and survey the line settled by Prinsep and Hodges between 1822 and 1829 [III, 141-4] or, where that line could not be identified, a new boundary laid down by the civil Superintendent. He started work during season 1849-50, and had to incorporate the work of Mullins, Surveyor to the Sundarbans[7], whose duty it was to survey the limits of holdings of the various grant holders. He reports that

the definition of the Soonderbund boundary will be a work of time and much labor, and... I do not feel at all inclined to entrust the duty to a subordinate. If it is to be done on my responsibility I must do it myself. ... The survey and definition...will commence near Rangafullah lighthouse, where I think I shall be able to recognise Captain Prinsep's starting point. ... I hope to erect a pucka pillar at this point[8].

He commenced on 25th January 1850 and was

delayed some days, ... unable to find a starting point from...the Hooghly River. ... Took up certain points marked in Capt. P.'s map—Bailtollah Diggee—Haukun Diggee[9]...the site of the

[1] DLR. 37/50 (2); DSG. to Wilson, 10-2-45; BRC., 5-3-45 (39). [2] BRC., 7-5-45 (5). [3] DLR. 37/74 (88), Smyth to DSG., 25-5-52; *IO Cal.* (458). [4] 22-6-47. [5] DLR. 39/68 (243), Smyth to DSG., 19-1-49; b. 37/62 (19), 15-12-49. [6] *Report* for 1849-50. [7] Chas. Wm. Mullins [IV, 400; V, 442]. [8] DLR. 37/62 (33), 27-12-49; B to OD. Rev., 27-6-50 (179-81). [9] *dighee* = tank.

old dak bungalow on the old road to Saugor Island—the site of the residence of an old Fakir... who resided there in Capt. P.'s time, as also the site of Roopnarain Potto pucka house, still in existence, and which spots I found to tally exactly with the map.

Taking therefore the site of the old dak bungalow, the remnants of which are still visible, as my starting point, I measured a distance of 9 chains down the old Saugor dak road which brought me to an old zemindaree bund...from which point I worked back towards the river Hooghly, taking bearings and distances, reversed, as given in Capt. P.'s field book. ... This measurement brought me exactly to the river's edge at a distance of two chains north of the present wooden telegraph at Cheeta Moomee. ...

I have marked off on each map the boundary of the villages adjoining Capt. P.'s line, and shewn also the line of dense impenetrable jungle as it now exists, ... together with the government bund and such other topographical features as came within my reach. ...

It would be useless entering into a detail of all the petty annoyances...I encountered...in having to deal with zemindars or their agents, in whose interest it was to lead me astray at every turn and corner, and to shew me any boundary but the one I was in search of. ...

These four sections...contain 90 miles of Capt. P.'s boundary line, and at least 150 more of Mr. Dampier's line. ... During the coming season I shall continue...as far as the Ichamuttee River. Capt. Hodge's maps...do not contain any boundary line but merely a topographical survey of the country to the eastward[1].

Smyth found that his line differed very materially from that adopted by Mullins for laying down the grant limits. He had, of course, made no attempt to show limits between one grant and another, but found Mullins' exterior line much at fault. Close survey by theodolite and chain was not practicable but, writes Smyth,

22 of my paces are exactly equivalent to one chain [Gunter's], and I so accustomed myself to this pace on the Soonderbund boundary that I could walk a mile or more and not be out a few feet. ... I went ahead with Capt. Prinsep's field book and maps in my hand, and watched the distances given in his field book. ... I have followed Capt. Prinsep step for step throughout in many places so well could I recognise the features of the country[2].

CALCUTTA SUBURBS 1846–52

The detailed survey of properties in the Government estate of Pānchannagrām[3] [IV, 192, n.1] had been commenced in 1841 by Michael Crow who was still engaged on this tedious task in 1846, assisted by his son and five "native surveyors", with 22 "labouring assistants". Crow's survey, reported Frederick Simms [181–2], was bounded

towards the city by the Circular Road and extends in width to near the Salt Water Lake [I : 13, 311 ; III, 13]. ... It commences with the river Hooghly at Chitpore and circumscribes the city outside of the Circular Road, and terminates at Tolly's Nullah eastward of Alipore.

Of six sections he found that only one was completed and plotted—three were

wholly surveyed but not entirely laid down, ... the 5th is in progress, ... and the 6th can scarcely be said to have been commenced. ... Upon the whole, I consider the work as very creditable to the skill of Mr. Crow, and will be a most useful map of the environs of the city. It is likewise well suited to be connected with the survey of the city [182–3].

Simms suggested that the city survey should now be given priority ;

I would suggest that the survey of the environs be discontinued for the present, and that the whole of the force now at command be set to work in the city. ... I am willing to undertake its superintendence and arrangement, Mr. Crow being the head of the surveying staff[4].

Before Simms' proposal was sanctioned the elder Crow died, and the Pānchannagrām survey was continued under his son. In May 1847 a suggestion that it should be taken over by Wilson's revenue survey was rejected as it had been surveyed in small disconnected patches and never "proved by traverse". In September it was placed under Simm's charge, and he reported that it had been

commenced in Jany. 1841, now nearly seven years ago, and...surveying, mapping, and the settlement...was to have been completed at the end of 1844. ... At the present rate...the mapping and calculations, without the settlement, of...No. 6 District will occupy another year and 5

[1] DLR. 37/62 (98), 27–8–50. [2] DLR. 37/74 (60), 17–2–52 ; *IO Cat.* (190), Rev. Svyr., 1847–52.
[3] *Imp. Gaz.* IX (286) ; XIX (378). [4] BRC. 22–7–46 ; from Simms, 30–6–46.

months. ... The two departments, the settlement and the surveying, are now separated, and ...should never be reunited again. The business of each is distinct. ...

Only one fair copy of each map is in progress; ... by constant references they will wear out and become useless, and new copies will have to be made from the delapidated ones which can never be so perfect as the originals, or as if made in the first instance. ... They will be liable to total destruction by insects or by fire, and...the survey which has taken so many years to execute will be lost[1].

In November 1848, the survey was transferred to Smyth's charge as "a legitimate part of the survey of the 24-Parganas District", and placed under Anthony Phillips, Smyth reporting in January 1851;

The survey of Puchanagram continues to progress. ... It is impossible to make much progress, not only on account of the crowded state of the thoroughfares, but also in the difficulties experienced in finding one's way through such a mass of houses and huts, and also in the difficulties of procuring attendance. Mr. Phillips has completed 12 sub-divisions comprising 3,028 holdings. ... Mr. Grote has asked me to increase the working establishment but I am unable to find a qualified surveyor for it at present[2].

In October 1851 there remained "only a part...consisting nearly all of cultivation. ... The 1st., 2nd., and 3rd. Divisions were done by Mr. Crow, and I will...compile a map also of them, and connect it on to my work though the interior of his work is far from complete". Smyth reported completion a few months later;

I have been obliged to detach 8 of my district surveyors to survey the topography of the 1st, 2nd, and 3rd. grand divisions which were prepared by Mr. Crow, no topography being represented on his maps beyond tanks, pucka houses, and roads. A general map of this Estate on the scale of 6 inches to 1 mile...is half completed. It is a minute detailed plan of the estate excluding boundaries. It contains also a skeleton plan of the City of Calcutta taken from Mr. Simms' map, together with the whole extent of the River Hooghly and some of the principal places on the opposite side, Howrah and Sulkeah, etc[3].

The large-scale block plans were bound up together in one volume, the three divisions surveyed by Crow being on scale 300 feet to the inch, and the remaining three on scale 150 feet to the inch. Separate statements for each division gave area of each holding, name of proprietor, and nature of tenure. A duplicate set was made for the Collector. Copies were also supplied to the India House for incorporation in the new General Map of Calcutta engraved from Simms' city survey [182]. Pending receipt of the engraved map, a Plan of Calcutta was compiled and lithographed at Calcutta on the 6-inch scale for the use of

the Conservancy Department...[shewing] the whole of the Environs in the Dhee Punchanagram, together with main lines of streets and principal objects surveyed by Captain Smyth. The interior of the town taken from Schalch's map of Calcutta...corrected...by the Surveyor to the Commissioners for the Improvement of the Town [III, 13][4].

The establishment was discharged on 1st August 1854. The cost of Smyth's survey from November 1848 was Rs. 11,368–4–11. The surveyed area of all six divisions measured 6,800 acres, the cost-rate being Rs. 165–0–6 per 100 acres[5].

NADIA & BURDWĀN, 1852–60

Early in 1852 start was made with the survey of Nadia District which runs north to the Ganges astride the rivers Hooghly to Matabhānga[6]. Connection was made with no fewer than 14 tower stations of the Calcutta Meridional Series [14–5, 296], and good junction made with Gastrell's survey of Murshidābād to the west and Pemberton's survey of Rājshāhi and Pabna to the north. Survey was completed in 1855 when the party moved west to Burdwān.

In May 1855, as an experimental measure, Smyth was entrusted with the double duties of Superintendent and Surveyor[7], and at once put in hand the settlement and

[1] BRC. 29–12–47 (20), from Simms, 25–9–47. [2] DLR. 37/62 (125), to DSG., 17–1–51. [3] DDn. 37/7; (55), 18–10–51; (64) 4–5–52; 37/74 (152), 9–12–52. [4] *IO Cat.* (192); MRIO. 44 (25–6); 45 (11–2)
[5] Maps on scales 6 and 12 inch to mile, MRIO. 43 (29, 30, 34–5); *IO Cat.* (193); cf. *Ben P & P.* III, 104 (122).
[6] *IO Cat.* (189–90), Nadia Dist. & 12-inch svy. Krishnagar town, Wm. Ivey, 1853–4 [7] with special allce. Rs. 200 from 14–7–55.

demarcation of boundaries, and the preparation of boundary *thakbasts* for Burdwān. By foresight and good organization he kept this preparatory work well ahead of survey [243];

> By 1st December, through the aid of additional demarcating eastablishment, and by admirable management, ... no less than 1,336 village circuits were ready for survey, and... the demarcation kept so well ahead of the survey that the large area of 1,578 square miles, embracing 1,929 village circuits, was accomplished without any hindrance whatever [301].

Cost rate was reduced from Rs. 31-3-0 per square mile for season 1854–5 to Rs. 21-11-6 for 1855–6. "A reduction of...one-third in the mileage rate...clearly evinces what an able and experienced Surveyor can do with a fair field before him. This outturn is the best we have had in Bengal for many years"[1].

Burdwān was completed by June 1857 when Smyth took furlough; he retired from the service the following year. Thuillier records that his surveys were

> in point of accuracy in the first order. ... Closing errors average 2·93 inches per mile over 23 distances compared. These favourable results...may be attributed to the care and judgement with which he conducted his main circuits, and the frequency of the observations for azimuth made by himself at every triple-junction point. ... The proof of...these computations is made by the Surveyor himself. ... The exterior sides of the main circuits are again extracted in this office for a Grand Traverse of the whole district, on which the compilation map is based, and these results have been in the highest degree satisfactory[2].

William Row, Smyth's assistant for two seasons, then took over charge and moved the party into south Dinājpur, but was sick the whole season 1857–8, and progress was poor. The majority of the Bengal establishment had refused to accompany the party on the move north of the Ganges and the staff had to be almost totally reorganized. James Sherwill took over charge in December 1858 and by 1860 the district had been completed by Nos. 1 and 2 Divisions [243].

Early in 1860 the headquarters camp suffered from two serious fires;

> The fire on 11th January last was caused by the surreptitious introduction of a light... within the office tent...by the burkundaz...in direct disobedience of the orders. ... Fortunately through the activity...of the Assistant...survey records were all saved. That of the 20th February was a continuation of the fire which...destroyed half the town of Dinagepore[3].

At the end of 1861 the party was transferred to Mānbhūm [243].

No. 3, OR EAST DIVISION: SĀRAN & TIRHUT, 1843–9

The survey of Sāran District had been started by Maxwell in October 1843, and in 1844 Wyatt took over charge of both professional and *khasrah* surveys under the direction of Charles Chapman, Superintendent of Survey. The object of the survey "was to map out the boundaries of the villages and estates in order to put a stop to the constant boundary disputes"[4]. Owing to disputes between the Rājas of Bettiah and Hutwah the Superintendent demarcated several of the *parganas* himself, the Commissioner noting that the objects of the survey were

> the legal definition and permanent record of the area and boundaries of every village and estate, and the construction of accurate village, pergunnah, and district maps. ...
>
> Owing to...the batwarrah laws [IV, 187 n.5] or to immemorial possession, the lands of four estates, for example, are found to be so intermingled field by field...that it would be impossible to make a separate map of each estate. The Deputy Collector who conducts the native survey, therefore, merely measures and maps the general boundary (or hulka as it is called) which surrounds and encloses the four estates.
>
> The map thus formed is sent to the professional Surveyor, whose survey parties measure every field or other portion of land within the hulka, noting the name of the estate. ... A khusrah map is then made shewing the position of each field and it's number. ... If there are any disputes...the khusrahs...are sent to the Superintendent of Survey who employs one of his Deputy Collectors to adjust the dispute[5].

[1] *GB Rev. 1855–6*; from DSG., 1-2-57; DDn. 624 (122); *IO Cat.* (174–5), 4-m. map Burdwān. [2] DDn. 624 (15); DSG. to Rev. Bd., 5-4-56. [3] DDn. 24 (39), Sherwill to DSG., 9-4-60. [4] O'Malley (126). [5] BRC. 3-9-45 (8), Comnr. Patna to Rev. Bd., 19-7-45; *IO Cat.* (165–7), Gaya, Patna, Sāran, Tirhut rev. svys. 1841–9).

During season 1845–6 the 2,665 square miles of professional survey included about 161 of *khasrah*. Start was then made on the survey of Tirhut to the east.

The boundary of Nepāl with Champāran to the north was resurveyed, the line having in 1817–8 been "marked by a trench and masonry pillars at every conspicuous angle [and] numbered from west to east" [III, 19–20 ; pl. 4]. A disputed section near Rāmnagar was "adjusted by a special Commission"[1] and, reports Wyatt,

I am proceeding but slowly with the boundary survey owing to Captain Abeebur Bisnath, who never appears on the ground before 10 or 11 o'clock, the early morning being devoted by him to *poojah* [prayers], and then to eating his "bhaut"[2], without which he never leaves his tent. ... I am obliged to suit the convenience of the Goorkha captain though at the sacrifice of my own duties. I hope, nevertheless, to complete the work ere long up to the Owria Nuddee, ... beyond which I cannot proceed until the Superintendent defines the boundary. ... I believe the Nepaul boundary to the north of Ram Nugger has been marked off by...the Joint Magistrate of Champarun, but Mr. Chapman has some work remaining there. ...

I hope to be in his neighbourhood in the course of a week, when I shall...come to some decision about...the survey of the frontier and the internal boundaries where the saul wood forest abounds. ... The survey of the Nepaul frontier from Mullye westward as far as the Ooriah Nuddee...bordering on talookh Ram Nugger has been completed, and, owing to the thick brushwood and high grass jungle within the saul wood forest below the Soomeshur range of hills, ... about 10 miles in width, I have been obliged to delay operations until the high grass be burnt, ... which is delayed to admit of the paddy crops being cut[3] [261].

Again on 12th January ;

I am again out on the frontier. I have surveyed the boundary up to the N.E. corner of Ram Nugger on the Soomeshar Hill, and have the whole extent westward along the ridge and as far as Tribanee Ghat to survey. This I hope to complete in 10 or 12 days[4].

The boundary survey was continued during season 1846–7 and 1847–8 ;

I joined the Civil Superintendent's camp at Bettiah on the 8th inst., and accompanied that officer...to the foot of the Soomeysur Fort from whence our operations commence. We have traced the boundary range through a mass of hills and forest. Several flags and conspicuous trees on the peaks...have been intersected and mapped. A few of the principal hill streams have been surveyed up to their source, and others as far as it was practicable[5].

And in his final report ;

The southern portion...was perfected in season 1845–6, and a route survey with the theodolite and chain was carried from the gorge of the Doon...through the Doon valley, ... up to Trebenee on the Gunduk. From thence round by the isolated tract of Rajpoor Shourrea skirting the forest, and uniting again at the starting point. ... My operations this season, therefore, were confined exclusively to the survey of the high Soomeysur boundary range, and to the formerly contested boundary through the forests and low hills. ...

In discovering the true boundary ridge described...in Captn. Boileau's map [III, 19–20] very great difficulty was experienced, ... for what with the paucity of inhabitants in the Doon, and the utter impossibility of getting them to show the boundary range (from fear... of...coming in collision with the Nepaulese), we were obliged to explore the country ourselves.

He referred to the necessity of "re-erection of the masonry pillars which have been destroyed by the encroachment of rivers". Instructions for the final numbering of the pillars were not issued until March 1849[6].

Amongst the tasks in Tirhut was the survey of both banks of the Ganges River for the sixty miles that it forms the southern limit of the Sāran and Tirhut districts. to lay down the village sites and other geographical items on both sides [245]"[7].

During 1846 a large-scale survey was made of the city of Patna where recess quarters were situated[8], and surveys were made later of the civil station of Muzaffarpur and of the "Poosah studlands" [III, 430]. These were on the scale 10 chains to the inch and, writes the Deputy Surveyor General,

all large towns, cities, civil stations, or military cantonments are to be executed on this scale or a larger one...and...you may...take either Dacca or Mymensingh in hand. ...

Another point...is the proper survey...of *roads* of importance. The Great Trunk Road, for instance, is very imperfectly shewn when surveyed piecemeal by the circuit system[9]. The road should be traced out regularly as a route survey, without interruption, and every

[1] BRC. 16–7–45 (2), 2–5–45. [2] cooked rice. [3] DLR. 36/31 (12, 15), 11 & 20–12–45. [4] ib. (45). [5] DLR. 37/58 (214–8, 222); 28–1 & 16–2–48. [6] DDn. 37/58 (271); 19–6–48; 36/27 (12), 19–8–48. [7] DLR. 37/56 (22), from DSG., 11–5–49. [8] *IO Cat.* (186–7). [9] various svys. GT. Road, *IO Cat.* (211).

place of note duly fixed on it. When left to a number of different interior surveyors the bridges, hauts [markets], encamping grounds, and objects of interest, are passed over[1].

At the end of 1849 the party was transferred to Dacca, which it reached about 22nd January 1850, and took up the survey of Mymensingh District.

Mymensingh & Dacca, 1850–60

Start was made in the south-west part of Mymensingh some 50 miles north-west of Dacca, up the Jenai or Jamuna River. Work was confined to professional survey as the *khasrah* had now been transferred to charge of the Superintendent, still Charles Chapman. The Great Trigonometrical Survey had not yet reached Mymensingh, and it was, therefore, writes the Deputy Surveyor General,

of the very first importance that...all permanent buildings and conspicuous objects...must be fixed...on your circuits, and entered...into the traverse as stations. ... These points can then be fixed hereafter by the G.T.S. without any difficulty [295–6].

The large rivers also will compel you to resort to triangulation, and to make this of any value for future amalgamation permanent pillars must be erected.

No less than 3 surveyors will connect with your work, viz.—on the west of Mymensingh, Mr. Pemberton for Rajshaye, or Bograh—on your north, Mr. Kelso, at present engaged on Goalpara, south of the Brahmapooter—and to your south-west in Furreedpore District Capt. Smyth will come up with the Jessore Survey [pl. 16]. You will not, therefore, fail to keep this object in view, and favor me with any suggestions as to the erection of puccka pillars. ...

I have examined Capt. Wilcox's and Capt. Ommanney's survey of the Jenaie, or Burrampooter, from Dacca to Goalpara, but data is not forthcoming, and I am not aware if any stations remain, but I should imagine not [IV, 265–6][2].

Much of the survey lay in undeveloped country and Wyatt reported at the close of his second season that

the density of the jungle, and the difficulty of obtaining assistance from the landed proprietors to point out their boundaries, and to furnish beldars to clear lines for survey, seriously interrupted my operations until the jungle fever prostrated my establishment and forced me to abandon the work and withdraw my men from so unhealthy a locality[3].

The northern *pargana* Susung[4], the estate of an important *zamindar*, ran some way into the hills, possibly

beyond the third high range within the mountains, ... extending as far as about 3 days journey northward from the plains. ... Everything involved in mystery. ... The settlement of the frontier line within this field season seems very problematical. ... A survey and a map of the country is necessary as a preliminary to fixing or defining the absolute limits of Mymensingh District on the Assam frontier. It will be impossible...without some idea of the country and of the claims of the Shooshung Rajah...clearly laid down on a map or tolerably accurate sketch.

A month later Wyatt returned from Susung

after putting everything into proper train, and seeing the greater part of the Turnai country surveyed. The survey of the principal hill streams and intersection of prominent peaks are progressing. The Garrows are a wild and dangerous race to deal with and awfully jealous of their wilds and fastnesses being surveyed. Mr. Jenkins [IV, 449] is the only person who seems to be able to control them [III, 49].

He asked if the Superintendent of the Khāsi Hills, now Hudson [IV, 200–2], could

meet us in person to point out the questionable boundary and by his presence and authority over the savage Garrow and Cosseah tribes not only ensure safety to the surveying establishment, but prevent collision between contending parties[5].

Thuillier advised him not to attempt a full survey into the hills ;

All you will be able to accomplish is to trace out the hill streams, ... lay down all the hill villages within sight, show the limits determined on. ... A complete topographical delineation of the Garrow Hills is beyond your competency, ... beyond the sphere of your duty. ... All that you can...do is to make an approximate sketch map of the ground. ...

In the evidence before Parliament [447] one of the most celebrated Engineers of the day stated his deliberate conviction that there were not 8 persons in the Ordnance Survey of

[1] MRIO. Misc., 12–0–59. Dacca, 12″ to mile ; litho. 1863 ; DLR. 36/33 (103), from DSG., 4–2–50. [2] ib. 4–2–50. [3] ib. (22), report for 1850-1, 27–12–51. [4] *Ben. Dist. Gaz.*, Mymensingh (164–7), pr. Rennell's Sosong Mountains [I : 20]. [5] DLR. 36/28 (101–3, 110), 25–2 & 10–3–56.

England and Ireland...who could draw ground from nature. Wherefore it must not be expected that a truthful picture of the Garrows can, under your peculiar equipment, be produced[1].

Wyatt's health broke down in 1857 after 13 years continuous duty, the last seven years in a most unhealthy district, and he was succeeded in charge by Nicholas Davey from Smyth's party [435]. The Mymensingh survey, including these 450 square miles of the Garo Hills, was brought to a close by the end of the year, when the party took up work in "Dacca Jalalpur", the north part of Dacca District.

Work in Mymensingh had been greatly prolonged by boundary disputes and no fewer than 742 appeals were dealt with by the Civil Superintendent; "many of them are sure to be again appealed to the Commissioner. ... Lands are so interlaced and are of such value that the area in dispute was frequently one, two, or three cottahs"[2]. This continued in Dacca;

The terrible evils which beset us in Mymensingh of never having done with the boundary dispute cases, of altering village plans one, two, and three, years after survey or demarcation, seem likely to cling to us in Dacca, and promise to prevent the best surveyors from ever finishing their records. ... The...minute sub-division of this district into no less than 108 pergunnahs and 63 tuppahs baffles all attempts to define them on the district, or even the one-inch block, maps. Out of all these only 5 or 6 pergunnahs are said to have defined boundaries; the remainder are broken up into minute portions[3].

In December 1860 after the completion of Dacca District, Davey moved the party into Sylhet where there were other problems to be faced;

In the rainy season the whole country becomes a perfect sea, the entire traffic and communications being...by boats. The village sites are raised on mounds from which even the cattle cannot move, but are fed on grass cut under water and brought into the villages[4].

No. 4, OR WEST DIVISION, SHĀHĀBĀD TO BĀKARGANJ

Shāhābād District was completed in less than two seasons between 1844 and 1846, the rapid progress being possible from the hill area in the south and the wide stretches of the Ganges River. Sherwill then moved to Monghyr where scattered areas had been surveyed by Egerton and Ellis between 1836 and 1838 [IV, 182–5].

On my arrival at Monghyr on 7th February [1846] I was surprised to find the Superintendent unable to give me any information as to the number of pergunnahs...to be surveyed, or their relative positions, ... nor were any lists, Persian maps, or thakbast missals procurable. ...

Commencing on the western boundary, ... I found that not a single attempt had been made to commence the demarcation, but by great patience and perseverance on the part of my surveyors I managed to survey three pergunnahs consisting of 380 hulkas [251] by the zemindars attending and pointing out the boundaries. In the meantime the demarcation... was proceeding by slow and tardy steps, but in so inefficient a manner as to be next to useless. ...

I completed 16 pergunnahs of about 1,635 square miles, 2,764 hulkas, 900 of which had no boundaries marked out. ... To test all my work with the hadbast maps [247], I made many ...attempts to obtain these documents...from the Superintendent, but without success. ...

Up to the 12th August, I had only received a few scattered thakbast missals of the whole zillah, amounting to 336 out of 2,764 hulkas surveyed. Several hundred disputes had been pointed out during my survey, and could not be settled till the thakbast missals reached my office. ... All my survey remains in my office incomplete[5].

During 1846–7 Sherwill extended survey into that part of Bhāgalpur District that lay to the south of the Ganges, but again he was delayed for lack of demarcated boundaries; "during the whole of the cold weather, November and December 1846 and January to February 1847, my office was either partially or entirely without work". During his absence on furlough Tickell held charge from March 1848, and completed the survey of both Monghyr and south Bhāgalpur, including the Dāman-i-Koh which covers the rough wooded Rājmahāl Hills [III, 137]. Start was also made in Bīrbhūm.

[1] DLR. 36/30 (24–7), DSG. to Wyatt, 26–11–56. [2] DLR.; *GR Rev. 1857–8*; from DSG., 2–4–59. [3] MRIO. Misc., 16–0–58; main circuit plots; Dacca. [4] *GR Rev., 1858–61* (166); Shaw & Smart; *IO Cat.* (178–9). [5] DLR. 37/66 (23), 11–11–46; MRIO. Misc. 13–0–46; 18–0–47; photo-zinco 1868; 20/1–0–47, Monghyr, 1" to mile, 1845–7; helio-zinco. 1880; *IO Cat.* (185), S. Bihār rev. svy., 1841–6.

On Sherwill's return in October 1849 he was distressed to find that much of the work carried out during his absence was of most inferior quality and had to be rejected. O'Donel had found gross errors in the traverse computations during the few weeks that he had held charge after Tickell's departure ;

An error of 20 chains in traverse circuit—an error of 100 degrees made in the calculation of the bearings. ... The field-books were made over to Mr. Parker who, by altering the distances and placing reliance in...doubtful angles, managed to complete the calculations. ...

It should not be difficult for an assistant of...25 years service...to distinguish good from bad work. It was his duty to have laid all the papers before either Mr. Chill or Captn. Tickell, and [to have] pointed out distinctly that the observations were doubtful, and the fieldbooks untrustworthy. ... But he continued to keep everything secret. ... The survey was bad, and he was not bold enough to report it as such. ...

The entire absence of any control over this work, the irregular manner it was carried on, ... and the...misapprehension of...his duties by Mr. Parker, have led to these results[1].

Sherwill found that the whole staff had been allowed to drift into slovenly ways and had been left entirely uncontrolled through Tickell's ignorance of the details of revenue survey, and his pre-occupation with administrative work. An area of 1,150 square miles had to be resurveyed during season 1849–50[2].

There was discrepancy with Tanner's survey of the Dāman-i-Koh [III, 137] ;

In a private conversation with Capt. Tanner at Monghyr, that gentleman informed me that the distances as shewn upon his map were not measured, ... but *mere estimated distances*, and, as the boundary in those days ran through a dangerous and an almost impervious jungal, it is not to be wondered at discrepancies appearing upon the distances being measured with instruments. ... No single distance as shewn by Capt. Tanner between any two pillars agrees with the surveyor's measurement, but the number of pillars [was the same][3].

During the next four years work proceeded through Bīrbhūm and into Murshidābād, whilst during the summer months of 1850 to 1852 a detachment surveyed an area of 630 square miles of the station and surrounding hills of Darjeeling [186]. Early in 1854 Sherwill was deputed on special duty as Boundary Commissioner [256–7], handing over to Gastrell who extended survey through Murshidābād and Bānkura into Jessore. Thuillier records that the party had been one of the old North-West establishments, ... brought down by Capt. Stephen...[IV, 184]. ... It came regularly on across the Sone River into Behar (Gyah) District, and thence Monghyr and Bhaugulpoor, south of the Ganges, after which Beerbhoom and Moorsheedabad, ... have been duly completed, thus forming a magnificent area of all the south gangetic districts. ...

The earlier surveys...cannot compare with what we have effected of later years. At the date at which those districts were taken up, the railway pace of the old North-West system prevailed, and Capt. Stephen was a true follower of that school, sacrificing accuracy and real utility to speed [IV, 215–8 ; V, 269–70]. Better things, however, soon began to take effect[4].

There was an unintentional break in the continuity of the programme from our imperfect knowledge of the true disposition of the districts in the Lower Provinces. ... After the completion of Beerbhoom and Murshedabad it was supposed that Bancoorah came next... south of the Adjee River, but it has since been discovered that Burdwan intervenes.

The Bancoorah District is, therefore, isolated from the others previously surveyed by the 4th Division, and after its completion it was necessary to pass over the intermediate districts of Burdwan and Nuddea and take up Jessore. During the season under review [1855–6] the operations of the party have been prosecuted partly in Bancoorah and partly in Jessore[5].

Work ran down to the Sundarbans and was much interrupted by rivers an tidal creeks[6]. It was most unhealthy and quinine was distributed freely [459] ;

Some of the intermediate boundaries of the small holdings or villages were laid down from simple chain measurements by prismatic compass and chain, or by triangulation where the swamp and jungle was impassible. The spongy morass, though often sufficiently firm and buoyant to support a man to walk on—water...oozing through at every step and warning him not to remain too long—afforded no stability for instruments. ...

Survey of...the resumed villages...was arduous in the extreme. Wading through mud and water, breaking their way through...reeds and thorns, and devoured by leeches and insects

[1] DLR. 37/63 (203), O'Donel to DSG., 10–10–49. [2] ib. (250), 30–11–49 ; Report 1849–50, from Rev. Bd., 10–10–50 ; 4 m. maps, Bhāgalpur & Birbhum *IO Cat.* (172). [3] DLR. 37/59 (29–30), from Sherwill, 15–12–53. [4] DDn. 624 (22), from DSG. 5–4–56. [5] *GR Rev. 1855–6* (26), from DSG., 1–2–57. [6] *IO Cat.* (188) Murshidābād & Jessore ; civ. station, Jessore, 1857–8, 8-inch to mile, C. Bradley.

during the day, only to be attacked by swarms of mosquitos and gnats at night, the men... suffered exceedingly. Mr. Henry Stevens...here exerted himself to the utmost, ... and Dowtal Singh, Kirtarat Pande, Seta Ram, and Mahomed Oomur, were conspicuous with their parties. ... The second...was so lamed by the bites of venemous insects that he had to be carried from station to station to observe his angles. ... None escaped. By no means the least of their inconveniences was the want of sweet water where all was salt or very brackish[1].

From Jessore the party worked east through Faridpur and into Bākarganj in December 1860[2]. In triangulating the great rivers

many difficulties had to be...overcome owing to the vapours constantly arising from the water, and the lowness of the banks obliging us to take our angles from stations often on a level with the water. It was by no means easy to get a steady and distinct view of marks across the river. In the mornings the fog was often too dense, and when it lifted but a short time was left ere the sun's rays...made the marks wave and dance beyond all hope of obtaining true readings. The nature of the banks, frequently composed of a thin stratum of clay over quicksand, made it difficult indeed to obtain a firm footing, either for ourselves or the theodolite. Cutting lines through heavy reed and gigantic flag jungles was a serious obstacle. ...

Not a man could be obtained to help us. ... We had, therefore, to do it entirely by the aid of our survey parties, and...to go ourselves at their head, and break through the jungle with them. The heat and exhaustion were great. But the men acted admirably and, reassured by us and our guns, had no longer any fear of wild animals with which these jungles abounded.

Latterly, when I reached the low jungly churs lower down the river I had the mortification of finding, and seeing sometimes as I looked through the telescope, my marks charged and knocked down by a wild buffalo[3].

During his first season in Bākarganj, 1860–1, Gastrell had the assistance of a young military officer, William Stewart, with whom he triangulated the great Meghna, fixing the distant shores of Tippera and Noākhāli and the river islands. Recess months were spent at Serampore where the town and environs were surveyed, whilst Stewart surveyed the powder factory across the river at Ishapore[4].

Thuillier records that this party was

one of the oldest and best in India, composed almost entirely of up-country men, some of whom can look back to the days when they were under the lamented Sir Henry Lawrence in the...N.W.P. [IV, 226–7, 453], from whence the party gradually worked down through Behar and Bengal, and for many years under...Major Walter Sherwill, now retired. ...

To the long training in the Monghyr and Rajmahal Hills and jungles under the above officer, and later under his talented successor Major Gastrell in the swamps and Soonderbun jungles of Jessore and Backergunge, I attribute mainly the great success the party has had.

The number of old trained men have, however, greatly diminished by sickness and death since the Jessore District was entered[5].

REVISION OF BOUNDARIES

In 1853, on recommendation by the Deputy Surveyor General, Walter Sherwill was appointed Boundary Commissioner for the revision of "civil and criminal jurisdiction boundaries". The Board of Revenue considered that "the pargannah groundwork on which the fiscal system is built cannot be disturbed", but recommended "the re-arrangement of mouzas, grouping them into convenient thanas or sub-divisions" [243]. They recommended the appointment of Sherwill as "Commissioner for laying down the boundaries of districts...in communication with the Magistrates and Collectors of each districts[6]".

Government directed that the object of this revision should be

to re-arrange the boundaries...in such a manner as should most conduce to public convenience and the efficiency of local administration, and also to possess the means of further re-arrangement when necessary by simple reference to, and alteration of, maps[7].

[1] *GR Rev. 1858–9*, from DSG., 21–4–59. [2] *IO Cat.* (178), Dacca & Faridpur, 1857–60, 4 m. to inch.; MRIO. Misc. 50, 56–O–61, Bakarganj 1-inch to m., MRIO. Misc. 49–O–59, 1″ main circuit charts, Faridpur, 1858–9, litho SGO., 1862. [3] Report by Gastrell, *GR Rev. 1859–60* (27–9). [4] MRIO. Misc. 56–O–61; 1″ map Bakarganj, litho. 1864; 50 (mm.), 50–O–59/60, main circuit plots; (106), Ishapore Powder Works, 24″ to mile; *IO Cat.* (177–8) Barisal, 16″, 1860–1. [5] *GR. Rev., 1858–61* (172). [6] *GR Rev.* LT. Rev. Bd. to Govt., 19–7–53 (19–20). [7] B to CD. Jud., 6–2–55 (92).

For more than twelve months from February 1854 Sherwill travelled through Bihār from one district to another consulting district authorities. He prepared full lists of the villages assigned to each separate *thāna*, and drew up maps to illustrate his schemes. The village names shewn on the maps were those in common local use, alternative names used for fiscal purposes only being noted in the register. The new thana limits did not necessarily conform to those of existing *parganas*; "the paramount object...is that of securing effective police administration...whatever the discrepancy...between pergunnah and thana boundaries"[1].

Thuillier was horrified at the magnitude of these changes which involved

compiling and printing an entire new set of maps, which is a hopeless business, and if the districts are to be altered at all, they should not be thus taken separately or in isolated cases, but collectively, so that the best general arrangement for the whole group may be made. ... Whatever disturbs the geographical features of the country, it will be my duty to object to. ... Dividing a compact pergunnah into two separate zillahs...will entirely upset the survey records and throw vast labour and expense in this Department[2].

Amongst conditions that had to be taken into account were—density of population—suitable sites for *thana* headquarters—good communications with outlying areas. The Ganges and other rivers had changed their courses since the earlier surveys of 1841–2, and the position of *diaras*, or sandbanks, and the riverain cultivation was completely changed.

Towards the end of 1855, after Sherwill had completed his recommendations for the eight districts of Bihār, he had to take furlough on medical certificate. On his return he extended the work into the lower provinces;

In the western districts...I was eighteen months settling the boundaries of 8 districts, having personally met every Commissioner, Judge, and Magistrate, for which...I spent nearly three months in travelling, going over one thousand miles.

In Bengal I have been engaged five months, and during that period by means of an active correspondence, one half of which has been of a demi-official nature, I have very nearly completed the boundaries of thirteen districts.

During the cold weather...the district officials are out in their districts, marching about. ... During the hot weather I should have every chance of meeting with the different officials when their district work is at an end, and they are settled down in their stations[3].

Thuillier was still unhappy;

The Boundary Commissioner's enquiries are tedious, and the progress made very limited. ... Alterations in sites of thannas as well as in the limits of their jurisdiction are continually presenting themselves, so that the revised maps issued after much labour of this office speedily become incorrect. ... Commissioners and other local authorities advance strong objections, ... and fresh propositions are everywhere rife. ... The fiscal boundaries are so perplexing and intricate, and so utterly useless for all practical purposes[4].

In November 1856 Sherwill was appointed Professor of Survey at the College of Engineering at Sibpur, without detriment to his duties as Boundary Commissioner. He made his headquarters at Dum Dum until he took leave pending retirement in May 1860. Two years later Gastrell was appointed to succeed as Boundary Commissioner.

[1] DLR. 39/68 (109), Jud. Dept. to DSG., 25–9–54. [2] ib. (58–62), 21/2–11–54. [3] DLR. 57/70 (49), Sherwill to DSG., 11–2–57. [4] *GR Rev. 1857–8*, from DSG., 2–4–59.

CHAPTER XVII

REVENUE SURVEYS :—UPPER INDIA—BOMBAY—MADRAS

UPPER INDIA : *Rohilkhand — North-Western Provinces & Oudh — Delhi — Rājputāna — Bundelkhand — Central Provinces & Berār* — PUNJAB : *Cis-Sutlej — Trans-Sutlej — Bari doāb — Rechna & Jech doābs — Sind-Sāgar doāb* — BOMBAY — *Sind* — MADRAS.

IN 1848 the Government of the North-Western Provinces asked for a re-survey of parts of the district of Delhi and of Rohilkhand, and more especially of the unhealthy forest *tarai* lands running along the foot of the Kumaun Hills. The revenue surveys of Rohilkhand had been carried out between 1833 and 1841 under Birnie Browne, George Fraser and James Abbott, in the districts of Bijnor, Pilībhīt, and Shāhjahānpur [IV, 221]. Though serving the purposes of revenue assessment, they were far from adequate for other administrative purposes.

The survey of Rohilcund is known to have been the worst in these Provinces. The establishment was the least efficient of any, and the natural difficulties to be overcome the greatest. The resulting inconvenience has been most felt in the northern pergunnahs adjoining the hills. ... The measures for draining and irrigating, as well as the natural increase of population and spread of cultivation is giving additional value to these lands.

An accurate survey of them is much required in order to give a secure title to land, and also to facilitate the construction of works for irrigation. ... These two surveys in Delhi and Rohilcund will not be mere revenue surveys. The rivers and lines of drainage must be laid down as accurately as the village boundaries. There will much levelling[1].

William Jones, now on canals [IV, 451][2], writes more freely ;

The revenue survey village maps are most incorrect, ... not at all to be wondered at when we reflect on the nature of the country and the quantity of work that the surveyors were expected to furnish in the given time. ... When they found themselves enveloped in a network of all but impassable nullahs, overgrown by high green reeds—...I may be pardoned a smile at the device by which they seem to have occasionally extricated themselves—the theodolite was closed, an imaginary circuit of zigzag lines drawn in the fieldbook enclosing an area of some square miles, and the note "Wild Elephants" told the rest. I have visited some of these...spots and found smiling villages and very fair cultivation. A change may have taken place, ... but when I see "Wild Elephants" I cannot refrain from a doubt[3].

Special tasks of the new survey included—

1st. The re-survey of such villages...incorrectly delineated by the former survey.

2nd. Lay down from the old survey...boundaries of all jungle tracts belonging to Government, and of all villages adjoining the jungle.

3rd. Formation of the Government forest land into convenient allotments for grants, each of which should be named and numbered, and the boundary marked off on the ground in some permanent manner, and separately mapped.

4th. Lay down with accuracy the course of all streams, ... basins of drainage, and sites of existing works of irrigation, and the position and extent of irrigated lands.

5th. The formation of pergunnah maps, scale one inch to a mile, shewing village boundaries and sites, and geographical features[4].

Areas for survey were estimated as—

Zillah Shahjahanpoor, pergunnah Poorunpoor Subna, and adjoining forest lands, square miles, 864—Bareilly, 953—Moradabad, 697—Bijnaur, 656—Saharunpoor, 1,092—Total 4,262 square miles, the whole tract...along the foot of the hills from the Sardah to the Ganges.

[1] DDn. 461 (409–14), NWP. to Home Dept., 28–3–48 ; Rean. of 11–5–48. [2] Supt. of Embankments.
[3] DDn. 465 (27–30), Jones to SG. 17–1–48. [4] DDn. 624 (36), DSG. to SG., 5–4–56.

Plate 16

INDEX

TO THE

Districts

IN THE

BENGAL PRESIDENCY

1855

Revenue Surveys before 1844

Lower Provinces & Bihār, 1844–61
(Ch. XIX)

- 1st, or N. Div., Pemberton & Smart.
- 2nd, or S. Div., Wilson, Smyth, & James Sherwill.
- 3rd, or E. Div., Wyatt & Davey.
- 4th, or W. Div., Walter Sherwill & Gastrell.
- Goālpara & Arakan, Kelso & O'Donel.

SCALE OF MILES

Reduced from Index, scale 96 miles to inch, compiled in Revenue Survey Office, Calcutta ; MRIO. 97(1)

For extension West see reverse

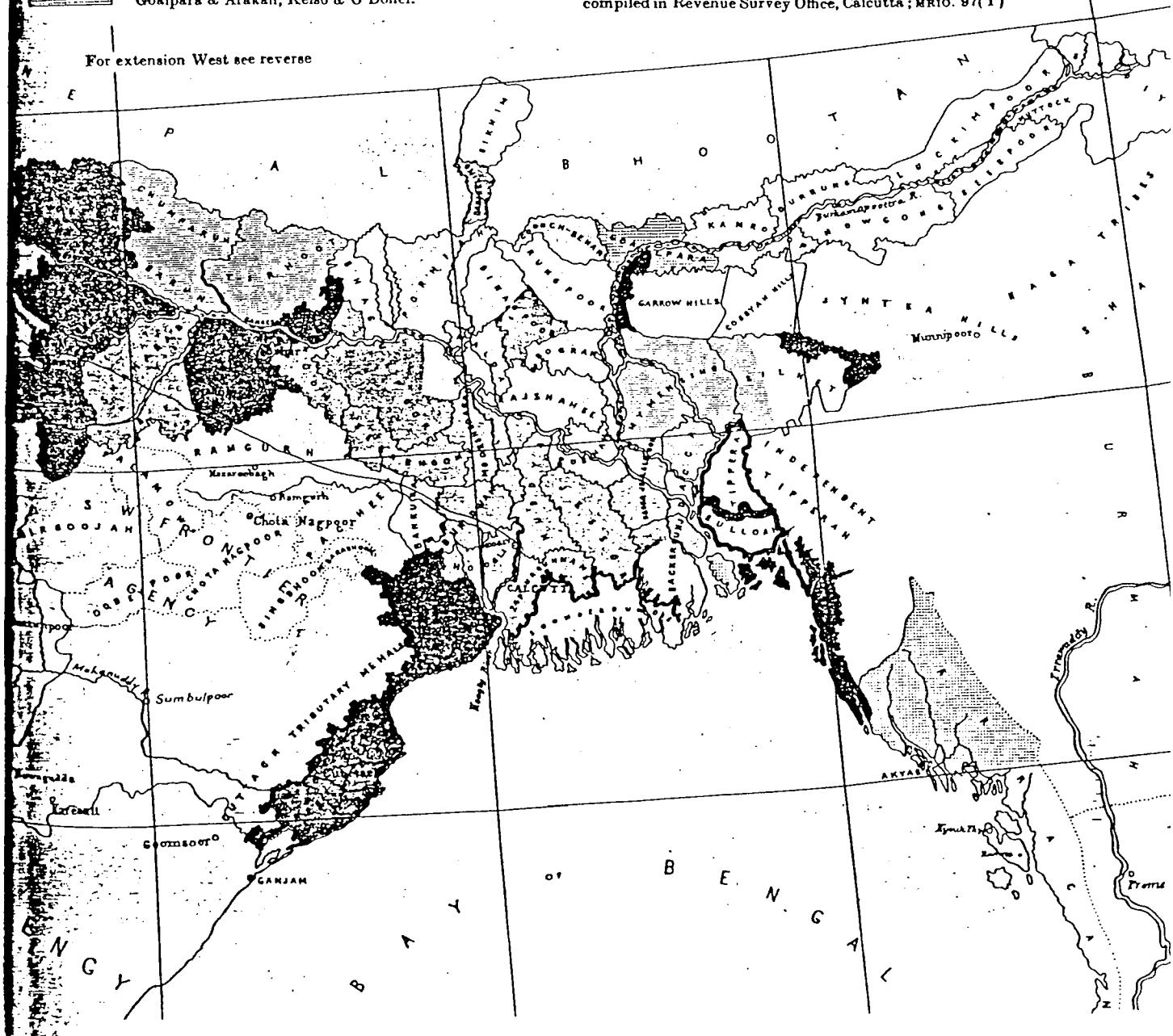
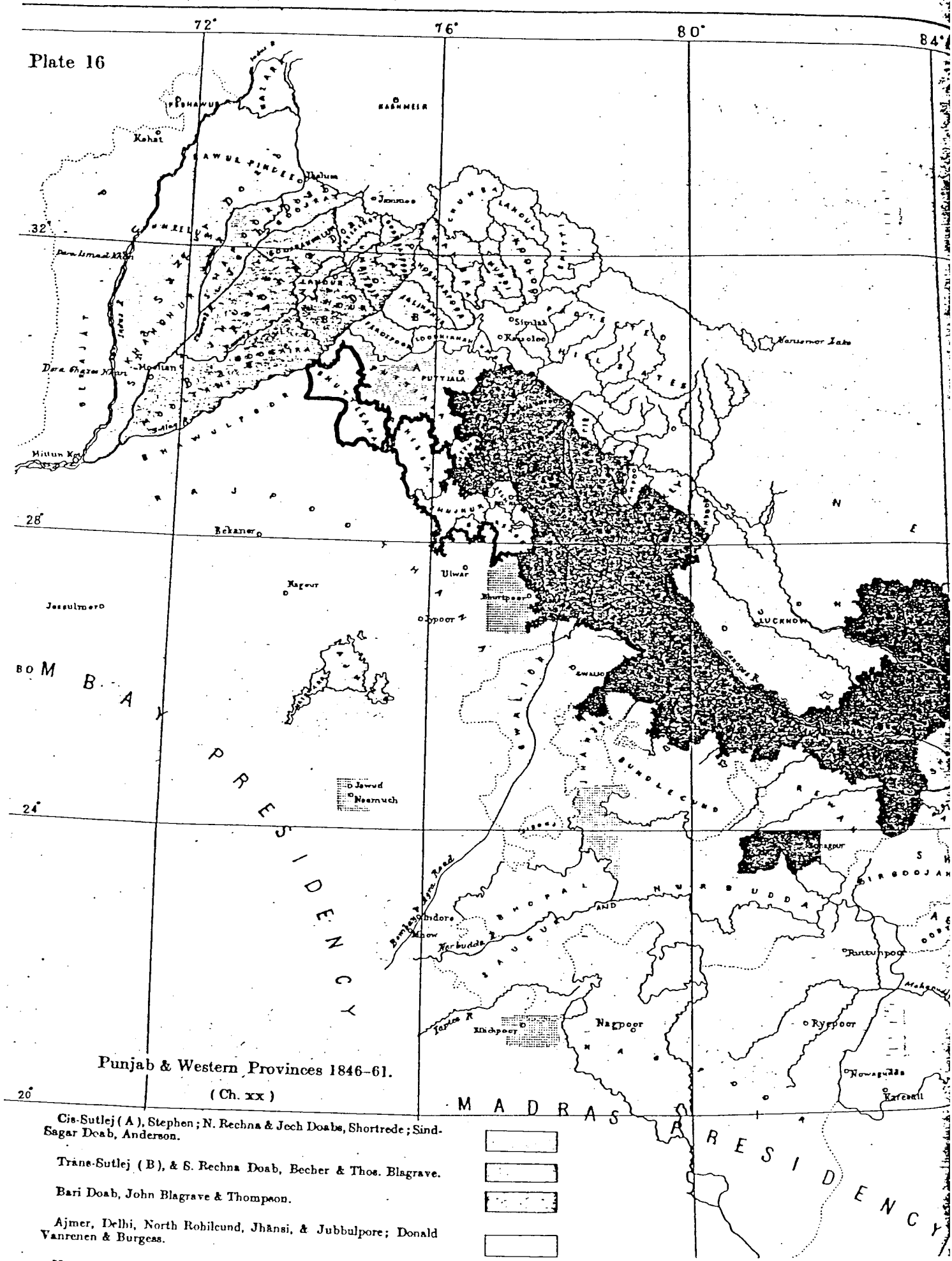


Plate 16



Punjab & Western Provinces 1846–61.

(Ch. xx)

Cis-Sutlej (A), Stephen; N. Rechna & Jech Doabs, Shortrede; Sind-Sagar Doab, Anderson.

Trans-Sutlej (B), & S. Rechna Doab, Becher & Thos. Blagrave.

Bari Doab, John Blagrave & Thompson.

Ajmer, Delhi, North Rohilcund, Jhansi, & Jubbulpore; Donald Vanrenen & Burgess.

The northern portions of the districts of Bareilly, Moradabad, Shahjahanpoor, and Bijnore, as well as the Kumaun forest, or bhabur tarae [IV, 473 ; V, 261][1], has been left almost untouched by the old survey, and the rapid steps of improvement had entered these forests and necessitated a complete revision. ...

The first and great object of this survey was to obtain the most perfect and minute topographical delineation of the whole tract—...the general fall of the ground—a fair and precise representation of every square mile—maps fit in every respect for the various schemes of local improvement...in contemplation. The forest had to be penetrated and the glades of grass divided from the ranker jungle, the hill streams traced out to their sources, swamps defined, and trees of importance and character blazed and notched for boundary marks, whilst the general levels and the accurate delineation of all streams and watercourses were intended for the better prosecution of the works...for irrigation[2].

Donald Vanrenen was given charge and started survey in Shāhjahānpur, November 1848, with headquarters at Bareilly. He wrote to the Collector ;

A survey party will leave this...for Shahjehanpoor early next month and...the survey of Poorunpoor Subna with adjoining forest land will be commenced in the beginning of November, provided your work is sufficiently advanced. ... I have received strict orders not to take up the survey of any circuit unless the village boundaries have been demarcated, and the thakbust papers are in my possession [247–8, 254]. ... May I...solicit...a moojmillee map of pergunnah Poorunpoor Subna as soon as practicable, as on the receipt I shall dispatch my line-cutters to prepare the lines[3].

Giving Hoppner and Burgess charge of detachments in Shāhjahānpur and Delhi respectively, Vanrenen himself took charge in Bareilly where he found 355 square miles of new village survey essential, since the old village maps showed

grave discrepancies between the boundaries of conterminous villages, making it doubtful which was the more correct. ... It was...necessary that the new maps should not only shew the course of all natural streams and artificial watercourses, but also the boundaries of villages through which they passed. The true boundaries could not be determined from the old maps.

In Shāhjahānpur 109 square miles were surveyed ;

Government forest lands, with villages adjoining, all surveyed as far as boundaries could be determined from records of former professional survey, and from explanations of local officers. ... Kucha pillars built along their boundaries will be replaced by pukka when the few disputes have been settled.

In north Bareilly an assistant was employed on levelling ;

Four circuits of levels have been taken, area 438 square miles. The levels have been calculated with reference to the kerb at the pukka well opposite the Tanduh police choki[4], which has been assumed as zero. Triangular masonry pillars, with a square foundation which is flush with the ground, have been built along the lines of level. ... The...levels exhibit a fall of 164 feet in 14 miles, or 11·7 feet per mile. ... The Bamoaree road levels...show a fall of 192 feet in 8 miles, or 15½ feet per mile. ...

The great sickness among the people is...in a great measure owing to deficiency of proper drainage, and to the number of swamps that are allowed to exist. Some of these swamps are formed from the reckless manner that...artificial watercourses are cut for irrigation purposes, the water not required by the cultivator being permitted to run waste to flood the low country.

During the recess months, of 1849 and 1850 a survey was made of Naini Tāl ;

A base was measured on the only spot suitable, ... a small level plain at the west end of the lake. ... Six-feet standard steel bars were used. Two careful measurements gave a length of 486·6 feet without...any perceptible difference. ...

A general map has been compiled and 46 estates surveyed and mapped. The estates have been surveyed like a village, and the superficial area of each given. The boundaries of each estate are inserted on the general map...with...the horizontal measurements. Mr. Sanderson's survey will undergo a searching examination...and...a map assimilating to the map of Mussoory by Capt. Wm. Brown [IV, 220–1] will be a matter of time.

The numerical data of the triangles are inserted on the Map of Nainee Tal, beautifully drawn by Mr. E. W. Hoppner...on the large scale of 8 inches to one mile. ... Separate maps of every estate having a definite boundary have also been lodged in the office of the Senior Assistant Commissioner, Kumaon, neatly executed by Mr. Sanderson[5].

[1] *bhābur* = porous ; absorbing mountain torrents beneath boulders & gravel ; *Imp Gaz.* XI (371) ; XXIV (133). [2] DDn. 624 (36), DSG. to SG., 5–4–56. [3] DDn. 485 (5), 20–9–48 *mujmal* = summary or abstract. [4] Tanda, 12 m. north of Rāmpur. [5] DDn. 485 (A 4–12), Reports for 1848–9 & 1849–50, 12–12–49 & 20–1–51 ; map of Naini Tāl on scale 12 inches to mile.

When the party entered Shāhjahānpur in December 1849 it was found that all old trijunction marks had been destroyed, and that the district authorities had not been able to demarcate the village boundaries afresh. The surveyors had, therefore, to lay down the boundaries "with the co-operation of the *zamīndars*",
the only deviation between the old and present boundary being that whereas the former was carried in innumerable and eccentric turns, the latter has been taken in straight lines from pillar to pillar. ... The consent of the zemindars to straightening the boundaries was obtained. ...

The boundary surveyed...between Bareilly and Shahjehanpore was obtained from the Shahjehanpore professional maps. ... The dispute about...the correct boundary...has arisen from the...common boundary *not* having been adhered to by former professional surveyors. ...

The survey in Poorunpoor Subna is comprised in one general map on which the Government forest grants are inserted and numbered. Separate maps have been made of each grant and bound in one volume; ... maps of 62 villages conterminous to the forest...in a separate volume. ...

In the teraee pergunnahs of Roodurpoor, Kulpooree, and Gudderpoor [of Bareilly], the detail survey has been thoroughly examined, and in many parts re-surveyed. In Gudderpoor especially the former...survey was so imperfect that all the principal rivers and gools [water-courses] have been re-surveyed, and fresh maps of the three pergunnahs compiled. ...

The country...is so extremely difficult of access, even when aided by elephants, and the season for surveying so short, extending only from February to the middle of April, that... a small gool or unimportant nullah may have been omitted because not seen.

During season 1849–50, village survey was completed in five other Bareilly *parganas*, three of which were allotted to Burgess on his arrival from Delhi in January 1850. The total area surveyed in Bareilly was 560·88 square miles covering 616 villages[1]. Lines of levelling were also run through Bareilly District during season 1850–1, Owing to the swampy nature of the country work in Morādābād could not commence till the beginning of January and in Bareilly not before the end of that month. Burgess had to withdraw his detachment on 11th April "owing to the very severe sickness that broke out".

Vanrenen thus describes traverse work through the *tarai*;

Anything like accurate chain measurement...must be out of the question. Even when lines are cut through the grass, the stumps are worse than before. I...directed the boundary surveyors in following out such streams to keep to the comparatively open ground above the high banks, and leave the interior surveyors to...survey...the contortions of their courses with the prismatic compass. [By] so doing...theodolite stations are likely to be of some permanency, while on the low banks of the river they are destroyed by the great floods, and for such intricate work...I look upon the prismatic compass as the better instrument of the two. ...

I had the positions of remarkable trees carefully noted and the trees themselves blazed with a cross, and...in the maps these are shown by a red cross with the name of the tree. ... A coarse carpenter should accompany each party for this purpose. ... Through the forest to the south of Bilheree I had strong tent pegs charred, driven into the ground, and the head covered with a ghura of charcoal turned upside down, and a mound thrown over the whole. ... They should be more permanent than even masonry pillars. ...

It is impossible to say what work there may be in the forest. There are portions that should be examined and any open glade surveyed, with the remains of any former villages. ... The forest is so thick and the brushwood and creeping plants render exploring no easy matter, even with elephants, having almost to cut one's way through it. ...

The surface of the pergunnah is one uniform plain, without a hill or rising ground to give a variety to the view, and from its proximity to the sub-himalayan mountains is much depressed towards the south. ... The nuddees...discharge their waters with great rapidily. ...

The main circuit of this pergunnah was surveyed by Hossain Baksh in 1849–50, a first-rate and most trustworthy native surveyor [264], and the field data put up and calculated by Mr.... Johnson. In the ensuing season he was detached to complete the survey of the village bounds and their details, ... making as complete a revenue survey as possible, noting every remarkable tree or object...to serve as landmarks for the guidance of the Collector's people. ...

A circuit of levels towards the close of the season was carried round the pergunnah by Sergt. Millard. ... Two cross sections, one along the high road, and the other following generally the course of the Gogee nuddee...were also conducted by him. The heights will be found... on the general map, as well as the several bench-marks established for...the canal officers. ...

[1] MRIO. 31 (67), Route Svy. to Naini Tāl, 1849–51; DDn. 485, Report for 1849–50, by Vanrenen, 20–1–51; Vanrenen, Burgess, Hoppner, Daniel Blyth, Sanderson, Edw. Johnson, Millard, Wallace.

The "hudbust" papers furnished by the Collector...were most deficient. ... They were rough rectilinear figures denoting the number of pukka pillars round the village, ... in several cases faulty and inaccurate [299–300]. Thus, whilst in...one village the pillars were put down two in number, those very pillars were noted in the adjoining village...as three, and straight lines drawn between them rejecting every notable object, even rivers and nuddees. ...

In...the former professional survey...in very few instances...—and those only when forming boundaries of villages—were the courses of large nuddees traced throughout. In most cases their entrances and exits were noted on the boundary, and no more, whilst every remarkable object and the consequent facilities for irrigation...were apparently forgotten.

Towards the close of the season...sickness was breaking out in every field party. The northern villages required extensive clearing of forest trees and long grass to enable the survey parties to trace out the innumerable hill streams and watercourses with tolerable accuracy, and the coolies who were sent at first never missed a favorable opportunity of decamping, leaving often their clothes and wages behind, so great was the dread of entering the terae, and the fatigue entailed on burning the rank grass [49, 252, 456]. ...

But...the months of April and May were the only ones for carrying the survey through the forest and grass, which could then be burnt down at less labour and cost than in the cold weather. ... I intimated...that I would leave no one behind, and would be the last to quit the pergunnah, and that only when I was satisfied with the accuracy of the work by a personal inspection. ... By the 1st of May the whole survey was complete. ...

The establishment took the field on the 29th November [1850] though no revenue survey operations were commenced till January owing to the state of the country. ... Adjournment for the recess was from...Bareilly...on the 10th April, and from Moradabad on the 1st May. In both instances sickness had broken out, ... those in...Bareilly...having suffered most[1].

In 1851, the survey was divided into two separate charges, Vanrenen taking the western, or Morādābād, area and allotting the Pīlībhīt and Bareilly area to Burgess. "The survey of the northern pergunnahs of Suharunpore is now in progress under Mr. Dodsworth, and need not engage Lieut. Vanrenen's attention [263]"[2]. Work during season 1851–2 for the west division lay in Chukhata *bhābur* of Kumaun [259 n.1], at the foot of the hills, about 203 square miles in area.

Lieut. Hamilton, who joined on the 27th of January, was...making a circuit of village levels. It was my intention to have furnished a complete set of levels of all the villages, but the cholera which had been raging throughout the field season breaking out with increased virulence in the northern parts of the bhabur early in March compelled me to withdraw my native surveyors. ... The survey of the Chukhata bhabur is comprised in 52 villages and 3 forest tracts. ... This small area...took the whole establishment 3 months, but...nothing could be done till January except village survey owing to the denseness of the forest.

The party was then withdrawn south to Rudarpur, where detailed survey was carried on till the end of April;

The professional survey of the 18 villages of...Kasheepore...which do not appear to have been included in the former survey by Capt. Browne, was commenced in the season 1850–1, and finished in 1851–2. Many of the boundary pillars having been destroyed during the rains, they were rebuilt. ... The work was entrusted to Mr. Hoppner[3].

Burgess's work in the Pīlībhīt area included

a minute revenue and topographical survey of the Deoha River...to facilitate the annual settlement of the alluvial lands, ... 77·5 square miles. ... Survey of the Bilheree forest and villages remaining incomplete from the previous year, ... 32 square miles. ... Survey of the Pilleebheet forest and villages adjoining...to...enable the boundary between the forest and villages to be permanently settled, ... 32 square miles. ... Survey along the Kala River, ... with levels to... [judge] the feasibility of draining the swamp. ... Survey of the Kumaon forest, or bhabur, between the Saidat and Sookhee rivers. ... Minute survey of the city of Pilleebheet. The resurvey of the newly settled boundary between pergunnah Poorunpoor and Beesulpoor[4].

On his triangulation along the Deoha River he used

a cheap and simple kind of reflecting signal, ... requiring no one to attend to it. Merely a piece of bright tin (a little quicksilver may be rubbed over it to increase the brightness), slightly bent in the form of a screw, suspended by a string over the station. This spun round by the action of the wind reflects the sun some distance[5].

[1] DDn. 485 (16); Report 1850–1, D. C. Vanrenen, 18–12–51; MRIO. 19 (37), *pargana* Bazpoor, Moradābād, 2-inch scale, 1850–1. [2] DDn. 562 (113), NWP. to DSG., 23–6–51. [3] DDn. 485 (19), Report 1851–2, Vanrenen, 10–12–52. [4] *IO Cat.* (220); MRIO. 17 (30, 31), w. Rohilkand, ¼-inch, 1846–54. [5] DDn. 485; Report 1851–2, Burgess, 23–5–53; also *NWP. Sel.*, III (228, 374), with maps.

In 1852, it was decided to employ Vanrenen's party for two more seasons, and that of Burgess for one only;

Lt. Vanrenen's party to survey the Ramgunga and Ganges from the southern limit of the Moradabad District as far as his party can reach by the 1st January, then to enter the forest of Kotah and Kasheepoor. In the following season, 1853–54, the work...will include a survey of the Gurhwal outer range of hills and dhoons. ...

Lt. Burgess will commence on the Ramgunga at the boundary of the Bareilly District, and survey down the river as much as possible till the 1st January. He will then complete his part of the forest and afterwards resume the river survey[1].

Vanrenen's riverain survey along the Ganges was of particular value, not only because the constant meanderings and floods of the river made earlier surveys long out-of-date, but also because these earlier surveys had not covered both banks. No riverain survey is, of course, of any permanent value unless it lays down permanent marks at a safe distance from erosion by the wandering waters [297];

Owing to the...absence of all connection of all the old surveys of the districts on either side of the Ganges River, the surveys...shewing the entire river with its sandbanks and islands and the lands of an entire village with all geographical features on both banks, are most valuable[2].

Of the similar survey along the Oudh bank of the Ganges opposite Cawnpore in 1860–1 [264], it was pointed out that "the value of these river surveys shewing all lands of secretion and decretion is not to be over-estimated. A similar survey in Rohilcund of the Ramganga and Ganges rivers and adjoining villages in 1852–3–4, was highly appreciated[3] ".

On the close of season 1853–4, Vanrenen moved his party to Jubbulpore.

In his report for 1852–3, Burgess describes work in the *tarai* ;

The jungle was heavier this year than it has been for years. The rain throughout January prevented it being burnt till late, and when I last passed through it at the end of last month [October 1853] a sea of waving grass covered forest and savannah alike. ...

The forest between Captain Ramsay's road, the limit of last year's operations, and the foot of the hills...has been surveyed...without incurring very heavy...expense in clearing lines, and sufficiently accurate for any purpose. ... The ground is broken into inaccessible ravines, and overgrown with thorny jungles through which it is necessary to creep. ... Regular tracks...are few and far between, especially in the east.

The heavy jungle below the hills...rendered it next to impossible to survey the peaks trigonometrically. ... The levels of the Mala swamp have been retaken throughout, and shew a surprising amount of fall...that will render the drainage a...comparatively easy matter. ...

Masonry chabutras, even with the ground, have been built at the theodolite station round each village triple-junction. ... These are to be covered with a mound formed of the earth dug from a ditch round them, and will protect the masonry from the worst destroyers of boundary pillars—cow-boys[4] [470].

Being now ordered to Bundelkhand, Burgess left for Cawnpore, where he spent the recess months of 1853, and made a survey of the city and cantonments [267] in a most minute manner on the scale of 20 inches to 1 mile. It contains an amount of work equal to two or three ordinary pergunnahs. ... The season has been the most fatal known for years...by the dreadful loss of life in H.M. 70th Regiment, and the European Artillery Company; one quarter of the entire regiment having been carried off.

The Cawnpore survey, though complete, still requires a good deal of examination, and probably correction, and—should the establishment again adjourn to this station next recess—it will be done...and a hydrographical map prepared...to assist the drainage arrangements[5].

Thuillier thought that the running of levels for drainage and irrigation projects would have been better left to a special party ; and did not think that this attempt at combining levelling *pari passu* with the revenue survey operations have answered any real practical end ; ... too much was expected from the Surveyor. ... The subject of contouring this part of the country in conjunction with the survey was...strongly advocated by the late Lieut. Governor [James Thomason, IV, 471], but was shewn to require special and independent agency, and pecuniary grants for its accomplishment, and accurate topographical maps for its delineation[6] [67].

[1] DDn. 485 (20), Report 1851–2, Vanrenen, 10–12–52. [2] DDn. 624 (38), ib. (38). [3] *GR Rev. 1858–61* (103); cf. *Riverain Surveys*; *SI. Records*, XXIV. [4] DDn. 485 (26), 24–11–53. [5] DDn. 485; Report 1852–3, Burgess, 24–11–53. [6] DDn. 624 (40), DSG. to SG. 5–4–56.

Similar requests had been made in the Punjab where the Surveyor General held that such work could not be undertaken by the revenue survey parties, though it was arranged to survey the canal bench-marks [67–8].

NORTH-WESTERN PROVINCES & OUDH

During Thomason's administration several surveys were carried out by district officers of the N.W.P. In Farrukhābād the *pargana* of Sukrawah was measured by the local authorities between 1844 and 1845, in order "to settle this pergunnah, though it is held as a zemindari, to protect the rights of the peasants"[1].

In Dehra Dūn, a re-survey was carried out during 1847 and 1848 under Alexander Ross, Superintendent of the Dūn, which superseded much of the work carried out by William Brown during 1839–40 [IV, 220]. The settlement based on Brown's survey had been made on a 20-year basis, but the failure then to demarcate any boundaries compelled "an entire remeasurement of every mouzah in the district"[2].

Comparison of the vernacular papers of the first survey with the returns of the late resurvey show the absence of communication between the Revenue and Survey officers, both previous to the commencement and after the completion of the survey. ...

No attempt appears to have been made...by the revenue authorities, to define the boundaries of each village. ... The zemindars...pointed out to the Surveyor...the boundaries they wished...which were, in the absence of disputes, surveyed and mapped accordingly. No care, however, was taken to ensure the erection of boundary pillars, by which alone was there a chance of preserving these limits [293].

Except in the highly cultivated tracts almost all the villages have, during the last 8 years, ... entirely altered both in shape and size. ... Some villages have become...enlarged to nearly double their orginal size, while weaker villages have suffered by...encroachment. ...

The general correspondence of the late resurvey with the English returns, and not with the khusrah measurements, prove that the original khusrah must in most cases have been very inaccurate. ... Whilst the admirably executed scientific village maps have lost half their value, the vernacular survey papers possess no value whatever.

I thought it best...to mark off the boundaries of each village according to existing possession, using the English maps as a check. In the resurvey the plan followed has been to mark off... the boundaries of each mouzah, ... and then to survey it, preparing a shujrah and khasrah of each [IV, 205]. ... The work of the ameens which closely followed on the demarcation...was... tested by...the settlement establishment, which again was followed by myself or the tehsildar.

The discovery of slovenly or inaccurate work entailed on the ameen a repetition of his labour without remuneration. A few such instances had the most salutary effect.

The Superintendent called attention to the great difficulty of procuring ameens in consequence partly of the demand for ameens in cis-and trans-Sutlej States, and partly of the laborious and unremunerative character of the work in a barren and uneven country like the Doon. ... It was not until I offered the unusually high rates of Rs. 4 per 100 acres, and Rs. 2 per 100 uncultivated acres, that I succeeded in getting any[3].

The only professional assistant that Ross had in this resurvey was William Dodsworth, the canal surveyor [IV, 390, 397; V, 261].

During season 1854–5, a small detachment under Hoppner was deputed from Vanrenen's party to survey the forest areas of north Gorakhpur that were being divided into grant blocks of 1,000 acres. The boundaries of 112 square miles were thus cleared and demarcated. A further 280 square miles was surveyed by another detachment under George Hamilton and then James Vaughan during seasons 1855–7. "In addition to his own immediate duties the sub-assistant has been employed in instructing ameens and putwarries for the local authorities"[4].

At the end of 1859 a revenue survey party under Frederick Anderson was moved down from the Punjab to take up the survey of the newly formed district of Partābgarh in the south-east corner of Oudh[5] [275]. Though the Chief Commissioner recommended that the professional survey "should partake more of a skeleton character,

[1] *NWP. Sel.* I, 1847 (249). [2] from Supt. Dun. 12–6–50; *Dist Gaz. UP.* I (103–21). [3] *Settmt. of DDn.* (17–61). [4] Svy. closed Aug. 1857; DDn. 485; Hoppner to Collr., 31–1–55; DDn. 624 (39, 51, 150), from DSG., 1–2–57. [5] Oudh tr. to British rule from Feb. 1856.

omitting the interior detail survey, which is not needed for the settlement purposes", the Government of India on advice of the Deputy Surveyor General directed that the survey should follow the lines of the Punjab surveys and give

the fullest detail as to all the specifications of land and the professional village maps on... scale...4 inches to the mile, replete with every information, ... the survey to show all topographical features which the scale is capable of representing. The interior detail measurement of cultivation, waste, fallow, is...carried out in all its integrity, ... a standard or basis where the native detail measurements of fields for settlement purposes can be compared and checked[1].

The *khasrah* survey was controlled by the civil revenue authorities.

Anderson had hardly started work in Partābgarh when he was deputed to the Nepāl frontier as one of the British Commissioners for the

settlement of the boundary between Oudh and Nepal. This Commission, composed of two British [Anderson and the Deputy Commissioner, Gorakhpur] and two Goorkha officers, assembled at Bhugora Tal north of the Taptee River on 25th January 1860, ... defining and laying down the line of boundary lately ceded by the British Government to Nipal [185].

Survey commenced from the old boundary near the Bhuchkewa Naka Pass north of the well-known fort of Bhinga...[and] joins the Rohilcund boundary at the village of Khujjoorea, district Shahjehanpoor, where the old pillars are to be found. Thus the new boundary line, measuring in its sinuosities 152 miles, is permanently marked by 211 masonry pillars. A large slice of the Khyreghur Forest, containing very valuable saul timber, and highly appreciated as hunting ground, ... has been made over to the Nipalese. ... It was also an object to restore to the Nipal Durbar their old...possessions as they existed in 1811 and 1816[2].

Anderson rejoined his party to recess at Naini Tāl by the end of May 1860.

A second party raised by Donald Vanrenen commenced the survey of Unao District in October 1860. Besides completing 926 square miles that had been properly demarcated in advance, both banks of the Ganges were surveyed [262][3].

DELHI

In addition to the survey of north Rohilkhand, the Government of the North-Western Provinces had asked for survey in the Delhi territories of the "decayed embankments" of the ancient canal system, and of the *pargana* of Kot Kāsim which had lately been taken over from the King of Delhi[4]. These surveys were allotted to a detachment of Vanrenen's party under Burgess and defined as—

1st. The topographical survey of the tract adjoining the city of Delhi on the south side. 2nd. The revenue survey of pergunnah Kot Kassim. ... 3rd. Laying down...boundaries of the several jagheers in Jhujjur, Lahoroo, Furrucknuggur, Potaondee, Doojana. ...

For the topographical survey...south of Delhi the Surveyor will check in the present revenue survey map by a series of triangles judiciously thrown over the whole. He will then furnish two maps...on the scale of 1 mile to 1 inch. One of these will shew the basins of the several lines of drainage, and the remains of the old bunds, and the other will shew the position of all the ruins and objects of archaeological or historical interest[5].

The revenue survey map here referred to was that based on Oliver's survey of 1822–8 [III, 155–6] as extended by Brown 1838–41 [IV, 218–9]. Kot Kāsim was surveyed by William Sanderson at the end of 1848;

The work is good in every way. The comparisons between the khusreh and professional maps were made by Lieut. Burgess, and where discrepancies existed a resurvey of the boundary was ordered. The villages contained...have all been made over to the Maharajah of Jypore[6].

The survey of the *jagīrs* was carried out by surveyor Husain Baksh [260], and consisted only in the traversing of their external boundaries and determination of their areas. Vanrenen instructed Burgess that it should be

surveyed in three or more convenient portions. ... Unless some kind of supervision is exercised ...on Hoosain Buksh's circuit survey as he completes each circuit, his work may turn out to be very incorrect. ... As each circuit is closed, it should be put up and proved by traverse. ...

[1] *GR Rec., 1857–61* (89–93). [2] ib. (77); MRIO. Misc. 64–0–60, ¼-inch map approved by F.D. 3686, 29–8–61. [3] Cawnpore Dist. lying on south bank. [4] DDn. 461 (409), NWP. to Home Dept. 23–3–48; Kot Kāsim, 55 m. SW. of Delhi. [5] DDn. 624 (36), DSG. to SG., 5–4–56. [6] DDn. 485 (A–15), Report 1849–50, Vanrenen, 20–1–51.

Working out traverse with logarithms, or by Boileau's Tables, is neither an exhilarating or interesting employment, but it is unfortunately a work which all revenue surveyors are at times obliged to do [t-page.][1].

Though Burgess describes the observations he took for controlling these circuits, both by bearings from trigonometrical stations and by azimuth observations, Thuillier considered the survey to be executed "in a very unsatisfactory style, ... the entire 900 square miles not presenting a single geographical point, village, or landmark"[2]. Burgess had indeed devoted most of his attention to the interesting area south of Delhi, including the traverse circuits from Kalkatola to Deri round by the Ridge, and thence to the Kutb Minar. ... This circuit was carried over the ridge of hills the whole way—over most difficult ground covered with loose stones and crossing numerous deep ravines—from which I expected an unusual amount of error, and had the above ...observations taken to check it. The long chain was used, and appears to have almost annihilated the effects of measurements over bad ground. and the error is so small...that it has not been thought worth while to make any corrections[3]. .... The traverses have been calculated by Lieut. Burgess, or under Lieut. Burgess's immediate supervision.

This southern area was commenced in February and completed in December 1849, the area covered being about 273 square miles. Thuillier was satisfied that this was of far better order, on which...Lieut. Burgess devoted much time and attention. A careful triangulation was thrown over the Delhi south pergunnah, and the basins of drainage minutely traced out, and a complete topographical survey...effected, with village boundaries inserted from the former survey, while the City and Ruins of Delhi, on the scale of 4 inches to a mile, has furnished a very valuable map in 8 sections[4].

Burgess himself records that he had

the walls of such of the old cities as could be traced followed out with the theodolite, and...I should have felt great pleasure in personally superintending this most interesting portion of the work, but the large amount of office work entailed...by the survey of the jaghires, and looking after my own native surveyors in addition to the triangulation, rendered this impossible.

I...propose to make over to the Society [ASB] a skeleton map of the district on the scale of four inches to the mile, with all the trigonometrical and accurate data connected with it, in which their discoveries about the sites of the old cities may from time to time be entered[5].

During 1850, Burgess moved his detachment to Rohilkhand though he was sorry to have to leave Delhi without extending triangulation over the whole of the *jagir* survey, and without completing his survey of the embankments ;

On commencing field operations in November [1849] I was unfortunately laid up with nearly the whole of my establishment with fever, ...and unable to go out and examine the work as I could have desired. ... Much of the second season's work, too, came in too late to admit of an examination before leaving the district. ... To these causes must in some measure be attributed rather meagre accounts...of the old bunds. ... It generally happened that—till my own native surveyors, or myself, had discovered them—I could learn nothing of their situation[6].

In October 1861, Henry Johnstone brought his party down from the fierce borderland beyond the Indus, to spend three years on the revenue survey of village lands of Ballabgarh, Gurgaon, Rohtak, and Hissār of the Delhi territories[7].

RĀJPUTĀNA

In June 1847, the Government of India authorized a revenue survey of the British districts, Ajmer and Merwāra[8], and the following orders were passed;

A considerable portion of the Ajmeer District and almost the whole of Mherwara being hilly, some modification of the usual system of the revenue system will be necessary. A professional map will be necessary for each village shewing the culturable area as well as the geographical features. ... Demarcation...has been already in great part effected. Application will be made...for the services of Lieutenant D. C. Vanrenen, artillery [269][9].

[1] DDn. 485 (appx. A–4), 23–11 & 28–2–49. [2] DDn. 624 (36), DSG. to SG., 6–4–56. [3] MRIO. Rev. Delhi ; trav. comps. [4] DDn. 624 (36), DSG. to SG. 5–4–56 ; map, *IO Cat.* (241), Delhi Fort & Cant., litho 4" to mile, but *S. pargana* map not found. [5] DDn. 485 (B–11), Delhi, 23–10–49. [6] DDn. 485 (7), Burgess to DSG. 21–1–51 ; Report on Bunds, 485 (x). [7] *GR Rev. 1857–61* ; SG. 12–9–62. Maps ; MRIO. Misc. & Rev. Hissar ; 8 (21) ; *IO Cat.* (258). [8] Ajmer 2,059 sq. m., Merwāra 902 ; ceded by Scindia 1818 ; under NWP., 1832–71. [9] DDn. 478 (3), NWP. Resn., 30–6–47.

The Deputy Surveyor General collected assistants, "tindals and clashees, all experienced hands" from surveys in Bengal, and ordered a survey based on triangulation on the lines of Wroughton's survey of Sohāgpur [IV, 228 ; pl. 14].

The smaller divisions or village boundaries are not defined, the denseness of the jungle and... small proportion of inhabited tracts rendering it impracticable and indeed unnecessary. ... The cultivated portions intervening between innumerable hills are traced out, ... and their areas calculated by triangulation, or a comparison with the khusrah where that is necessary. ... Necessity for a khusrah measurement in each district rests with the local civil authorities. ... If an assessment is to be made, then of course the khusrah is absolutely essential[1].

Vanrenen, with his assistant Burgess, had both been employed on Stephen's cis-Sutlej survey and, writes Thuillier, had "adopted the principle of quantity without considering the quality of the work". They completed the survey of this hilly area in the one season, except for a small area in south Merwāra ;

Mairwarra was only delineated topographically. ... The maps, both pergunnah and village, were altogether of an inferior character, and much below the standard expected from, and furnished by, other surveyors, exhibiting great haste in their preparation, and want of uniformity in the representation of the topographical details.

After the rains of 1848 the party was transferred to Rohilkhand [259], and the final maps were submitted from Bareilly[2].

In 1854, a new party was raised at the request of Sir Henry Lawrence, now Agent to the Governor General for Rājputāna, for survey of Nimach-Jāwad, 140 miles south of Ajmer. Lawrence was insistent on the urgency of the task and obtained the appointment of Captain Dennys, Commandant of the Kotah Contingent, although he had no survey experience. The Deputy Surveyor General was hard put to find men and materials ;

No adequate notice was given, ... and stores and equipment and instruments and staff were difficult to find. ... The Lt. Governor imposed the additional provision that it must be completed within one year. ... Difficult as the task was, and disheartening as the prospects at first appeared, the undertaking was commenced and prosecuted with...vigor. ... Capt. Dennys proceeded to the scene...accompanied by a first-rate assistant, Mr. Johnson [260 n.1, 436], and a few native surveyors, etc., made over to him by Capt. Vanrenen, an arrangement made at Nynee Tal without reference to this office.

Dennys was a good organizer, and was ably assisted by Johnson from the Rohilkhand survey who "set the survey on foot on the principles generally observed in the Department". The work was connected with the Great Longitudinal Series, and 1,189 square miles were surveyed by the middle of the second season. Thuillier was "much pleased with the result; the pergunnah maps...would do credit to any of the existing surveys".

Dennys reverted to his military command in February 1856, and the bulk of the establishment was moved to take up the survey of Bharatpur under charge of George Hamilton from the Gorakhpur forest survey[3] [263]. Fieldwork was completed by the end of season 1856-7, the Rāja bearing the expense.

The important duty of demarcating boundaries well in advance has been admirably carried out by the Superintendent...under the instructions of Sir Henry Lawrence, A.G.G., who as an old surveyor fully anticipated this want[4].

The Surveyor General was particularly pleased by his inspection of the first season's maps at Dehra Dūn in November 1857 ;

I am much gratified...by the style of execution. ... The completion of your surveys...is a most important matter for the new edition of sheet 50 of the Atlas; ... the old edition is very bare of information as regards native States. ... The rebellion apparently has done scarcely any harm to your party, ... on which I cordially congratulate you [483][5].

Although portions of this party were out when the rebellion commenced, they met with no disasters beyond the loss of a small portion of their records. Mr. Young was cut off from the headquarters, ... but after many adventures was able to render very good service at Delhi where he served with the rank of Lieutenant in command of the Jheend Raja's artillery[6].

[1] DDn. 478 (2), DSG. to SG. 24-11-47. [2] DDn. 624 (31), DSG. to SG. 5-4-56 ; maps, *IO Cat.* (260), litho. ½-inch. [3] DDn. 624 (47), DSG. to SG., 5-4-56. [4] MRIO. Misc. 128-O-71 ; litho. 1", with rlwy. inserted later. DDn. 624 (147), DSG. to SG. 1-2-57. [5] DDn. 645 (339), 9-11-57, SG. to Hamilton. [6] DDn. 665 (393), SG. to DSG. 12-11-57 ; Robt. James Young [444].

As Burgess's field work on the northern borders of Rohilkhand drew to a close during field season 1852–3 [262], the Government of the North-Western Provinces directed that he should move his party into Bundelkhand

and commence the survey of the northern part of Kuchwahanghur, where the Scinde River falls into the Jumna[1], whence the survey will proceed southward through...pergunnahs transferred to British management from Scindia and the Jhansee Raja, and also the territory of Jaitpoor. ... When these are completed the survey will proceed southward and westward into the Saugor and Nurbuddah Territories [IV, 287 ; pl. 3 ; V, pl. 16]. ...

Lieutenant Burgess's establishment...will be raised to its full strength, and will thence be regarded as an ordinary survey party. ... The Superintendent of Jaloun will...assign it work... between the Scind and Jaloun. ... As soon as the season terminates the survey party may move for the hot weather and rains either to Cawnpore or to Kalpee[2], or Humeerpur as may be found convenient.

Delayed at first by numerous boundary disputes, Burgess completed 2,266 square miles during the two seasons 1853 to 1855 [189] ;

Owing to the intricate intermixture of the Jalaun and Humeerpoor district pergunnahs prepared first for survey, ... Lieut. Burgess was employed on odd jobs—irrigation and works of improvement in Mohoba and the Jhansi pergunnahs, also the drainage and levels of the cantonment of Cawnpore [262], with road surveys and estimates—constructing a road from Nowgong to Jhansee and various other extra-professional matters. ...

Lieut. Burgess has thus been employed two seasons and a half in Bundelcund, but...little has been sent to this office. ... From a natural tendency in Lieut. Burgess's character to...aim at many objects without accomplishing much, anxiety has been felt. ... His managment of the survey duties entrusted to him has not been so systematic and regular as could be desired. The interior details of a single village in Nohaba are stated to have occupied a month or 6 weeks, ... carried out with a perfection never before attempted, and which he has been enabled to do through the agency of the planetable. ...

The pergunnah Jaitpoor, covering...of 900 square miles, was surveyed by triangulation by Lieut. Fuller, and the computation of his triangles have been duly rendered but the map has not yet...reached me. ... The demarcation maps have been...unreasonably delayed[3].

During season 1855–6 an area of 452 square miles was carried out in "pergunnahs Mow and Pundwah of the Jhansi District, recently lapsed to the British", besides 852 square miles of "a topographical survey of all the minor native independent Bundela States and jagheers interlacing with the above". In 1857 a dreadful disaster overwhelmed the party when every member was massacred at Jhānsi on 8th June [483].

Work was resumed nearly two years later by the Bharatpur party which had not taken the field during season 1857–8[4]. The party under Adrian Vanrenen reached Jhānsi early in February 1859, soon after its re-occupation, and took over such survey records as were found in a sadly mutilated state in the Fort. The remaining months of the season were spent in arranging the old records and "making good... all the gaps caused by the destruction or loss of the field books and field sections, ... 144 square miles". The area covered by 1-inch topographical survey in Chhatarpur, Tehri, and Orchha States, was entirely resurveyed ; "It is a disagreeable job for one surveyor to map the field work of another"[5].

During the next two season Vanrenen's party completed survey of the Jhānsi and Lalitpur districts partly with village surveys scale 4 inches to a mile, and partly with one-inch topographical survey[6].

CENTRAL PROVINCES & BERĀR

Though the Government of the North-Western Provinces had proposed a revenue survey of the Saugor and Narbada Territories as early as 1847, no party became available until after the completion of the Rohilkhand survey when, in October

[1] a few miles below the Chambal. [2] DDn. 563 (74), NWP. Rev. Dept. Resn. 29–1–53. [3] DDn. 624 (43–5), DSG. to SG. 5–4–56. [4] Geo. Hamilton left for pol. service, Feb. 1858. [5] *GR 1857–62* (55). [6] Asstt., Sconce, Talbot, Kelly, H. L. Pemberton, Ward, Brennan, J. S. Pemberton.

1854, Donald Vanrenen moved his party southward to take up the survey of Jubbulpore, basing his work on stations of the Calcutta longitudinal series. During the two seasons 1854 to 1856 he completed 1,334 square miles.

At the same time a second or western party was raised by John Blagrave who started survey of the Saugor District in season 1854–5. On his death in 1857, charge was taken over first by Willoughby and then by John Grant.

Both Jubbulpore and Saugor districts now became the scene of serious disturbances and military operations, and both parties were diverted to take up areas in the neighbourhood of Nāgpur to which work was closely confined during the first season 1857–8 [486]. Survey of the whole of that district was completed by the end of season 1859–60.

The Surveyor General considered that it would be wrong to base this new survey of Nāgpur on the old triangulation of 1823 to 1830 [III, 90–3]:

> In my opinion...it would not be desirable to let Captain Vanrenen's work depend on that basis. The best plan...will be for...[Mr.] Mulheran...to project a new branch series into the heart of the Nagpore District, and thereby place trustworthy data...at Captain Vanrenen's disposal. ... Upon the basis afforded by this branch series Captain Vanrenen could with perfect confidence carry on either a network or system of series covering the whole district[1].

During season 1858–9, therefore, Mulheran, with a detachment of his Hyderābād party, ran a branch series from the Great Arc eastward to Nāgpur, a matter of about seventy miles [179].

In March 1859 Vanrenen took furlough, handing over to Oakes who moved the party back to Jubbulpore in November 1860. The second party under Grant took up the survey of Bhandāra in season 1860–1[2]. In 1861 Adrian Vanrenen moved his party from Bundelkhand to make the third party working in the Central Provinces.

Local revenue surveys had been started in West Berār after the formation of the Central Provinces[3] [II, 133 n.1; IV, 257 n.3], and during Mulheran's first months at Ellichpur preparing for resumption of the Hyderābād Survey [178], he made himself useful to the civil authorities in teaching the putwari ameens employed in the settlement of Northern Berar the mode of surveying villages by the chain and cross staff, using the planetable at a check upon all measurements made in the field. The success which attended Mr. Mulheran's instruction of these men elicited for him the thanks of the Resident and the civil authorities[4].

Markham records that in 1856 Meadows Taylor[5] organized a survey of "Nuldrug District", adopting a plan of

> working by back and forward sights only, as with a theodolite. The method was readily learned by native assistants, who became wonderfully expert and correct. The work had been cheap and comparatively rapid, and when tested...with the points of the Great Trigonometrical Survey it had proved very satisfactory. ... Colonel Meadows Taylor was ordered to prepare ...for the revenue survey of the whole of the assigned districts, of which he was to have been the head, but the Mutiny broke out in 1857 causing a suspension of work, and when quiet was restored a part of the Bombay Revenue Survey establishment was set to work in Berar [400–1, 444][6].

PUNJAB: CIS-SUTLEJ, 1843–55

The district revenue surveys of the North-Western Provinces had been closed down before the end of 1842, having fulfilled the immediate requirements of the settlement officers. In 1843, William Brown [IV, 424] was recalled to survey *tehsil* Kaithal, a small Sikh State that had lapsed to the British[7].

> The object was to survey estates...for revenue purposes. The khusrah map, worthless for topographical purposes, was the important part. ... The scientific department was only intro-

[1] DDn. 665 (436), SG. to DSG. 5–5–58. [2] MRIO. Misc. 258–O–1869, Bhandara Dist., 4 m. to inch. [3] *Imp. Gaz.*, VII, Berār (422). [4] DDn. 549 (180), SG.'s Report 1855–6, Jan. 1857. [5] Philip Meadows Taylor (1808–76), Col., Nizam's mil. service 1824–60; CSI. 1869; *DNB*; *DIB*; Cadell. [6] Markham (119–20). [7] now part of Karnāl Dist., S. of Patiāla.

duced as a check upon the native ameens, and to enable the Surveyor, by putting together the village maps, to form pergunnah and zillah maps. ...

Expedition was also a great object. The survey stood on the threshold of all operations for determining the Government demand upon the land. Till the survey was completed Government was kept out of the enhanced revenue to which it was in some instances entitled, whilst in others the people were burdened with undue exactions. ... The revenue officers were dependent on the surveyors for a great number of statistical details quite unconnected with science, and perhaps distasteful to men of scientific acquirements[1].

Brown took up this survey in September 1843, but during 1844 was called away to military duty. The work was completed and extended to other parts of Karnāl District by Saunders Abbott [IV, 417] who was in civil charge of settlement operations. Charles Foy, an assistant of considerable experience, continued in charge of the professional survey[2].

As a result of the 1st Sikh War 1845-6, the Jullundur *doāb* lying between the Sutlej and Beas rivers was ceded to the British [2, 7, 34]. A North-West Frontier Agency was formed under an A.G.G. with headquarters at Ambāla, with two Commissioners in charge of the cis- and trans-Sutlej Territories respectively[3]. In July 1846, the Governor General directed the formation of two survey parties,

to commence operations as soon as the season will permit, one to survey the districts north, the other those south, of the Sutlej. These surveys to be under the superintendence of the Deputy Surveyor General. The surveys will be conducted according to the rules laid down for the...North-Western Provinces, and will embrace the same details, care being taken to render the maps as useful as possible for military purposes. ...

The Governor General will appoint...practised officers to superintend these surveys. ... Captain S. A. Abbott, Deputy Commissioner, ... will superintend the entertainment of the subordinate officers[4].

Henry Stephen [IV, 468] was appointed to survey the cis-Sutlej territories, which included the Sikh *jagirs* which had now fallen to the British. The civil authorities had made no preparations for the survey and, writes Thuillier,

the cis-Sutlej States, embracing the country between the Jumna River on the east, the regulation districts of the North-West Provinces, Paneeput, Rohtuk, Harrianah, and Bhuttianah on the south, and the Sutlej River on the west and north, was entrusted by G.O. of 10th October 1846 to Capt. H. V. Stephen, ... an old N.W.P. surveyor who had just returned from furlough, and Lieut. D. C. Vanrenen, ... at that time employed on the canals in Sindh, was appointed assistant. ...

Both as to the extent of the establishments[5], and the time of commencement, this Department was not consulted. For the graver errors, therefore, of throwing an expensive machinery into a district where it has not the means of exercising its functions or, in other words, for keeping up a costly professional establishment without providing it adequate work, this Department is in no way responsible. Revenue enquiries and preparations...should precede...a professional establishment by at least one year [349-50].

Captain Stephen...commenced work in the Umballah District in November 1846, and for several seasons...produced very large outturns. ... Vast areas were got through, some...being regular village-by-village work, and some merely survey in the lump, i.e., topographical survey only, on the one-inch scale. In the British portion where the village-by-village division prevailed, all the details of cultivation and waste have been given.

The khasreh, or detailed native measurement of the lands of every village coming under settlement, was taken out of the hands of the Surveyor...and placed under the settlement officer. The professional survey progressed so fast that the khasreh never kept up, and the comparison between them will have to be made at a later date, entailing the deputation of another professional surveyor.

Having completed the survey in five seasons 1846 to 1851, Stephen then took furlough.

The survey covered no less than 15,520 square miles, Ferozepoor, 2,813—Loodhianah, 1,550—Umballah, 1,965—Thanesur, 2,324—Independent native States, 6,870 square miles.

[1] DDn. 451 (47-51), NWP. to SG. 7-3-44. [2] *Punjab Sel.* XXXI (27-9, 46); MRIO. 8 (16), ½-inch map; Rev. Svy. Kaithal & Ambāla. [3] Treaty of Lahore, 9-3-46; John Lawrence, Comnr., trans-Sutlej. [4] DDn. 461 (57-60) FD. Resn. 30-7-46. [5] J. Foy. Kavanagh, A. B. Blaney, Burrowes, Loftie, Housden, A. Foy, Howard, & 34 native assistants.

It did not include the 1,383 square miles of Khythul which had been previously surveyed by the late Maj. Wm. Brown [268–9]. ...

... Capt. Stephen's maps...[are] a great source of anxiety to the Deputy Surveyor General. ... [They are] not only ill-drawn, and greatly handled and damaged, but they contained many inaccuracies, and the topographical portion of the Native States was meagre and unsatisfactory for compilation purposes. ... It has been found necessary to employ...Mr. Kavanagh...to revise boundaries, resurvey lapsed jagheers, and correct the old maps after comparison with the khusreh maps from the date of the conclusion of the original survey to the commencement of the present season of 1855–56 [396].

In February 1851 Robert Shortrede took over charge at Ferozpore, and moved the party up to Siālkot to start the survey of the Rechna *doāb* [273]. Kavanagh remained behind at Ambāla to clean up the records which were, writes Thuillier,

a monument of the system by which difficult operations of settlement and survey were prosecuted in a new country, and of that preference for large area and cheap rates which characterized all this surveyor [Stephen]'s work [255].

Season	1846/47	surveyed 1788	square miles, cost rate	Rs. 19– 9–0
	1847/48	4185	,, ,,	Rs. 10–12–2
	1848/49	4653	,, ,,	Rs. 9– 9–5
	1849/50	4112	,, ,,	Rs. 10–12–1
	1850/51	783	,, ,,	Rs. 33–14–2 [272].

Mr. Kavanagh has had a most...difficult duty to perform, and he appears to have done it very satisfactorily. ...: He has now placed the records in such an intelligible state that we may hope for a correct...General Map, which...has been a crying want for years past[1].

In addition to the regular village and *pargana* maps and traverse records, Kavanagh submitted to the Deputy Surveyor General in May 1855—

A. 18 plans of villages of District Hissar; shew new boundary between these villages and the Putteala State. Surveyed October 1853. Originally surveyed by Wm. Brown in 1840 [IV, 218–9].
B. Plan of three pergunnahs of Futehbad transferred from Patiala to Hissar.
C. Plan and area table of Imrutpoor and two other villages transferred from Thanesur to Paneeput.
D. 37 village plans, pergunnah Jhoonsur formerly belonging to Kythul, District Thanesur, but were given to Putteeala Chief in 1846 in reward for services rendered during first Sikh War.
E. 76 pergunnah plans of the Kythul portion of Thanesur; ... shew revised pergunnah boundaries.
F. 21 plans of puttees in District Umballah, Ludhiana and Thanesur, surveyed by Maj. Wm. Brown.
G. 18 plans of puttees surveyed by Maj. Abbott in Districts Thanesur and Umballa[2].

In 1857 Thuillier reported that

a new map of the whole of the Cis-Sutlej States has just been completed on the 4-mile scale after an immense amount of work and correspondence with local authorities. This compilation it is proposed to lithograph here to prevent further loss of time and disappointment[3].

The village maps of the greater part of this survey, neatly bound with traverse details, have been preserved in the Map Record and Issue Office of the Survey of India, and were transferred to the National Archives in New Delhi early in 1955[4].

TRANS-SUTLEJ TERRITORIES, 1846–51

Charge of the trans-Sutlej survey covering the districts of Jullundur and Hoshiārpur in the plains, and the rough hill district of Kāngra, was given to John Becher, who had Hutchinson and Thomas Blagrave as assistants[5]. Work for the first two seasons, 1846–8, was confined to traverse control and topographical survey of Jullundur District covering nearly 1,650 square miles.

The Settlement Officer did not enter upon his duties till the survey had been some time in operation. The thakbust papers were not received till October 1847. ... Not a single fair copy of a plan had been made by the 1st October 1847, owing to the uncertainty of boundaries[6].

After Becher's transfer to the political department in October 1847 and Hutchinson's death a year later, Blagrave took charge from December 1848[7]. Whilst two detachments took up the survey of Hoshiārpur District a third was kept in office to clear off the arrears of mapping caused " by non-receipt of thakbust

[1] DDn. 624 (52), DSG. to SG. 5–4–56. [2] MRIO. Rev. Svy., Ambala; *IO Cal.* (254). [3] DDn. 624 (153), DSG. to SG. 1–2–57. [4] MRIO., Rev. Svy series. [5] also W. & G. Blyth, Permien, Ellison, Keane & Jackson. [6] DDn. 483; Report 1846–7, Blagrave, 28–2–50. [7] his bro. John holding ch. for a few months before going sick.

maps"[1] [IV, 205; pl. 8; V, 247–8]. The field surveyors ran into the same disturbances that had struck Du Vernet's triangulators [35] and had to break off work hastily, to resume at the latter end of February. The greater part of what had been previously done during December and January had to be re-done owing to the hurried manner in which some of the parties had to quit the scene of their operations, one mootsuddie having been seized by the insurgents and sent across the river; his theodolite, chain, and other instruments, as also those of a second native surveyor, being seized by them [35].

Hoshiārpur District being "half hill, half plain" had to be covered with small triangles, and the whole of Kāngra, which could not be entered till "the latter end of March", was triangulated from one of Du Vernet's principal triangles [35]. There was a great deal of fever "and one of our best draughtsmen, Beharee Lal, died on the 27th April". Field work for 1848–9, lay entirely in the hills, of which 1,795 square miles were surveyed[2]. Mapping progressed slowly;

Plans of 5 pergunnahs [Jullundur] have been bound up and might have been considered complete...but for the want of statistical accounts, and numerous discrepancies in their boundaries..... Both the rivers Sutlej and Beas have been resurveyed along the whole course from opposite Roopur on the one, and Talwara on the other, down to Pupoortullah pergunnah[3]. ... The course of each river has changed so considerably since 1846–7, that the original professional survey was not of the slightest use as a check on the khusrah measurement.

The greater part of the thakbust maps of both the Jullundur and Hooshiyarpoor districts having been found so totally untrustworthy and incorrect, having been made before the various boundary disputes had been finally adjusted, ... the Settlement Officer and myself...condemned them in toto. ... We then appointed a committee consisting of my assistant Mr. G. H. Blyth and Mr. Depy. Collr. Mussun Ally, who in the space of one month completed the comparison and revision of the whole khusreh and professional maps of two pergunnahs.

The general map could not be finished off because the boundary between the Hoshiārpur and Kāngra districts had not been finally settled[4] and co-operation with the Settlement Staff continued to be difficult right to the end of the survey;

The numerous changes of settlement officers, and the hurried manner in which the last officers brought up their work and deserted the survey—the repeated alteration of...boundaries and orthography—each of the six officers having had a system of spelling of his own. ... The inaccuracy of the lists furnished, which...were left to clerks...to compile, ... was...a source of great delay and inconvenience [248][5].

Survey was carried well up into the Kāngra Hills to the fringe of Kulu [301];

I have marked the boundaries of kothees wherever habitations...existed. But when the limits of the kothees ascended to higher regions, uncultivated and rarely visited by man, I have not attempted to trace out the...boundary, and beyond the level inhabited by man the vast forests and fields of snow—which are an object of no desire or contention among the people—may be considered as common ground. The only portion of Kooloo that can be surveyed ere the winter is over and the snows have cleared away is the southern portion... adjoining Kangra Khas, but as soon as the passes are open every available hand shall be set to work in Kooloo proper, and Lahoul, so as to complete them if possible in one season.

[Season 1849–50]: Chota Kooloo, a narrow strip extending across the first snowy range, between...Chamba and Kooloo proper down to the Ravee, about 50 square miles, the lower half of it up to an altitude of about 12,400 feet, I myself surveyed in October last [1849] assisted by Mr. Bennett and Govind Pershad[6].

The attempt to carry survey further into the hills through "Barra Boungal" towards Chamba had to be abandoned and their survey left to Du Vernet's topographical party [202, 204–5]. About 500 square miles of the earlier work had to be revised, and two assistants who shirked the more difficult hills were dismissed.

Right through the survey the *khasrah* had rested with the Settlement Officers, and the Deputy Commissioner, Kāngra, describes departures made from conventional procedure when working in the hills;

Measurements were not entirely new to the people. They possessed a local standard of their own. Before our time assessments had been fixed according to the dimensions of each man's holding. I discarded the "field map" or shujrah, altogether. Its compilation is always a work of infinite labour and difficulty, and never could have been prepared by the

[1] *IO Cat.* (244–5), ¼-inch map, Jullundur 1846–8; litho., 4 sh. [2] MRIO. 7 (28–9), ¼-inch map, Hoshiarpur, 1849; MRIO. Rev. Svy., Hoshiarpur & Kangra. [3] by Du Vernet's asstS. [202]. [4] DDn. 483; Reports 1848–9 & 1849–50, T. C. Blagrave. [5] ib.; Report for 1851–2. [6] ib.; Report 1848–9 & 49–50.

agency I employed. Even where a professional ameen is employed its utility is scarcely commensurable with the labour and time it consumes. ... Kangra proper contains 2,600 square miles, of which 2,000 were measured and assessed. ... I commenced the measurements in October 1849, and I had finished the assessment in April 1850. During the hot weather and rains I measured and assessed Kooloo, Lahoul, and Spiti, and I shall complete the settlement of the Hoshearpoor Hills, 1,500 square miles, by the end of the current year 1850, having commenced measurements in August[1].

Though commending Blagrave's work Thuillier thought little of that of the earlier seasons.

Large areas appear to have been alone thought of, without reference to future consequences, and the village boundaries were taken up and surveyed even prior to demarcation and adjustment of disputes, entailing serious and heavy revisions.

The detail of the survey was...satisfactory. The plains...were conducted in the usual style of the...traverse circuit system, but...the whole of the hills from the low ranges of Hooshyarpoor to the snowy elevations of the Kangra District, are on a trigonometrical basis. ... This part of the work was conducted by Capt. T. C. Blagrave in close connection...with the principal triangulation of the Himalaya Series of the G.T.S., and the results are highly satisfactory[2].

Season	1846–47	surveyed 1795 square miles; cost rate Rs.	21–2–5
	1847–48	2151	19–7–1
	1848–49	1795	23–5–7
	1849–50	1042	43–2–8
	1850–51	357	101–5–0 [270].

BARI *doāb*, 1850–9

On 29th March 1849, at the close of the 2nd Sikh War, the whole Punjab was proclaimed a British province, and placed under charge of a Board of Administration at Lahore[3]. There was an immediate call for surveys.

The Bari *doāb* lies between the Beās and Rāvi rivers and covers the districts of Gurdāspur, Amritsar, Lahore, "Googaira" (later Montgomery), and Multān [pl. 16]. Rough sketch maps had been made in 1849–50, for the lay-out of the canals under Col. Robert Napier, Chief, or Civil, Engineer[4]. In October 1850, a small party was raised by John Blagrave from the trans-Sutlej party, and started work in the Gurdāspur District then called Adinanagar. The professional survey was to co-operate closely with the Settlement Officer. Assessments were to be based on the superficial details...found by the professional survey. The most minute...accuracy was not only demanded, but the areas...of these details as well as of the villages were demanded. ... Survey...demanded all the energies of the European portion of the establishment, and naturally entailed a large amount of office agency and considerably reduced field progress. ...

The abolition of the native agency, and the prevention of the importation of Hindoostanee ameens into the...Punjab, was declared to be of paramount importance, and the settlement requirements were...met by accepting the returns given in by the local proprietors, ... checked by the professional survey. ... At first the duties were extremely onerous; ... the demands for returns by the Settlement authorities were pressing, the assessment following close on the heels of the survey. In the first season of 1850–51, 1,015 square miles...were accomplished at a rate of Rs. 35–5–11. The next season, 1851–52, the area was increased to 1,635[5].

The following general procedure was now adopted by all the Punjab parties;

The boundaries of villages are defined and recorded, their areas surveyed, classified, and mapped. Besides the scientific survey which furnishes a complete map of every district and every village, there is a second survey executed solely by natives, which furnishes a faithful return of every field in each village.

The scientific survey gives the interior areas, divided into cultivated, culturable, and barren waste, with the site of the village, of wells, roads, marshes, and other marked features.

The field survey gives a complete return of the dimensions of every field, the name of the proprietor and cultivator, the character of the soil, and the nature of the crops. Formerly

[1] Report by G. C. Barnes, 29–11–50; *Punjab Sel.* 1, 1852–3 (30). [2] DDn. 563 (262), DSG. to SG. 1–8–54; ib. 624 (55), 5–4–56. [3] Presdt. 1849–53 Sir Henry Lawrence, till succ. by his bro. John as Ch. Comnr. [4] MBIO. Misc.; 13–0–49; road svy., Gurdaspur, C. Blaney, 1849; *IO Cat.* (139) canal svys. [68 n.5]. [5] DDn. 624 (59), DSG. to SG. 5–4–56 *IO Cat.* (247–8), Multān Dist.

this work was performed by hired measurers who...became very unpopular. There was no doubt but that they levied considerable contributions from the people, though the returns they furnished when fairly supervised were wonderfully correct[1].

Survey of the Gurdāspur District—covering Pathānkot and a considerable area of hilly country—with the hill station of Dalhousie—but excluding the area west of the Rāvi in the Rech *doāb*—was completed in the three seasons 1850 to 1853[2]. From season 1852–3 charge passed to Hunter Thompson, who extended the survey into Lahore District, and then into what is now Montgomery. Multān District was completed by 1859, after which the party was transferred to Chota Nāgpur [244].

The work sent in both by Lieut. J. W. Blagrave and Capt. Thompson has been excellent; not only very carefully conducted, both as regards the general disposition of the main circuits, and the style of the interior details, but the maps are all...most creditable.

Instead of...taking up all the pergunnahs for the congregated maps of village jurisdictions on the one-inch scale which form the basis of the topographical work, the surveyors were directed to follow any compact circuits...of symmetrical sides and fewest observations, and to map these main circuits...without reference to the subsequent...operations of the settlement operations. This enabled the Surveyor to send in all his topographical maps season by season, ... and the hands of the Surveyor are unfettered by any arrears. ...

Arrangements have been made for keeping...demarcations well in advance of the survey[3].

RECHNA & JECH *doābs*, 1851–5

The Rechna *doāb* lies between the Rāvi and Chenāb rivers, covering the districts of Siālkot, Gujrānwāla, and Jhāng, and parts of Gurdāspur, Amritsar, and Lahore [pl. 16]. During 1851, Shortrede brought his party up from the cis-Sutlej survey to start work in the upper, or eastern, division which included the northern *pargana* of Gurdāspur and the district of Siālkot[4]. Thomas Blagrave's party from Jullundur was assigned to the lower, or western, division.

Major Shortrede, in this and the following season of 1852–53, having completed...2,015 square miles, left the remainder of the doab for Captain Blagrave, and crossed the Chenab into the Jech, or Chuj, doab, the smallest of the five doabs, which...extends from the territory of Golab Singh near the hills to the junction of the two rivers [Jhelum and Chenab ; pl. 16].

In his first season Shortrede's party only surveyed 664 square miles owing to the "minuteness of the survey", to which they had been unaccustomed. Outturn increased to 1,351 square miles for season 1852–3, whilst for the two seasons after the move beyond the Chenāb it increased to 2,113 and 3,969[5]. It was to control these revenue surveys that lines of minor triangulation were run along the rivers during season 1850–1 and the meridional chains expedited [37, 52].

The Jech *doāb* to which Shortrede moved lies between the Chenāb and Jhelum rivers, and covers the districts of Gujrāt and Shāhpur. More than 80 per cent was waste land that could not be irrigated from either of the rivers. "Great difficulty was experienced...in procuring good drinking water, the present wells affording only brackish water fit alone for camels". Traverses were based on stations of the Jogi-Tila Series [51–3], and the survey was completed by 1855.

In December 1851, Blagrave sent a camp from the trans-Sutlej survey under George Battye across the Rāvi which surveyed 350 square miles of the Lahore District during season 1851–2. In May a second detachment under William Lane added a further 241 square miles by October 1852. Blagrave himself remained at Hoshiārpur until October 1852, working on the heavy office arrears of the Jullundur *doāb*. With the full strength of his party, outturn for season 1852–3 came to 1,342 square miles, which was pushed up to 2,540 and 5,649 for the next two seasons. These areas included the central upland tracts of "*bar*" or desert, the whole of which was "minutely traversed and every feature well delineated [52]".

[1] *Punjab Admin.* (104). [2] Maps, MRIO. 5 (12); 14 (2); Misc. 17–0–63; 19–0–52; Rev Svy. Gurdaspoor; *IO Cat.* (240), by John Blagrave, 1850–2. [3] DDn. 624 (26), DSG. to SG. 5–4–56. [4] MRIO. Misc. os. 17–3–11, Sialkot, 1851–5. [5] DDn. 624 (64), DSG. to SG. 5–4–56.

The survey of Hafizābād in western Gujrānwāla "was a work of no small labour and time" owing to the wooded nature of the country, "but by dividing the district...into small-sized circuits, each assistant was enabled to keep his line-cutters well ahead of him[1]." On the completion of Jhāng District Blagrave handed over to John Macdonald who took the party down to Sind [277].

SIND-SĀGAR *doāb*, 1855–9

The Sind-Sāgar *doāb* lies between the Indus on the west and the Jhelum, Chenāb, and Panjnad rivers on the east, and covers the Hazāra, Rāwalpindi, Jhelum, Miānwāli, and Muzaffargarh districts. A wide area is covered by the *thal*, or desert, above the reach of irrigation. The *doāb* is traversed by the Salt Range which runs in a south-west direction from Jhelum, the area to the north being known as the *kohistān* or hill country.

These upland districts, Hazāra, Rāwalpindi, and Jhelum came under topographical survey by Robinson, and it was a matter of debate as to whether they required regular revenue survey in addition, or whether Robinson's party could meet revenue requirements by making special survey of village and other administrative boundaries. It was decided that survey of boundaries was impracticable so long as they remained unsettled and undemarcated[2], and copies of the topographical survey proved of great value to the Settlement Officers [211–2, 284–5].

In August 1855, Shortrede was directed to take up the village-to-village survey of the "lower districts of Khangurh and Leia" which cover the present districts of Miānwāli and Muzaffargarh together with that part of Shāhpur that lies on the right bank of the Jhelum. The Commissioner had suggested that

> a topographical survey should be made along both banks of the Indus from Kalabagh to the border of Sindh. ... We have no correct map of that tract...[other than] surveys along the Indus made by Lieutenant Wood of the Indian Navy [IV, 277–8], and other officers. ... Those surveys are most accurate as I have had ample opportunity of testing, but they do not extend beyond a few miles on either bank of the river, and it is a great desideratum to have a good map ...from the southern base of the Salt Range...down to the confines of Sindh. ...
>
> In the central thul of the Leiah District a revenue survey would only entail a useless expenditure, but the kutchee pergunnah[3], and a strip...along the left bank of the Indus from the Salt Range to Mahmoodkote, ...4 to 10 miles in breadth, and about 180 miles...north to south, to its junction with the Khangurh District, is an exceedingly rich and productive tract[4].

Working from the south during season 1855–6 Shortrede surveyed north to the confluence of the Jhelum and Chenab, and about up to the parallel of Dera Ghazi Khan. The total area surveyed was 3,620 square miles, of which 2,071 is mouzawar, or regular village circuit and detail—1,110 thull or desert—and 439 square miles of river. A small party was detached...in December 1855, under Captain Johnstone to commence the survey of Derajat west of the Indus [217–8]. ... The party recessed at Murree, ... and prior to taking the field again the services of Lt.-Col. Shortrede were placed at the disposal of the Commander-in-Chief. .... He made over charge...to Lieut. Anderson on 12th November, 1856[5].

Instructions were issued for proper junction of Anderson's revenue survey with Robinson's topographical survey to the north. The southern base of the Salt Range was to be the general limit, "without any blanks, defects, or omissions", allowing Anderson's survey "to include complete districts". There was no objection to Robinson accepting Anderson's survey of strips of cultivated land running into the hills, since both surveys were based on the same triangulation, and, notes Thuillier, "it is the invariable practice...to carry the operation somewhat beyond the limits of the district boundary, and to include as much of the topography of the adjoining zillahs...as can be conveniently embraced"[6] [213].

[1] DDn. 483; Report, 1853–4. [2] Boundaries survd. 1861–2, *GR. Rev. 1858–61* (122). [3] *kachchi* = land flooded every year. [4] DDn. 641 (73), from Comnr., Leiah, 20–11–54; Khangarh Dist. [pl. 16] formed 1849, re-named Muzaffargarh, 1861, with limits modified. [5] DDn. 624 (158–9), DSG. to SG. 1–2–57. [6] DDn. 664 (206), DSG. to SG. 29–7–58.

The base of the hills, where they debouch on the plains, was carefully surveyed by Capt. Anderson and...Lieut. Penton Thompson, as well as the senior assistant, Mr. Housden, by throwing a series of minor triangles from the measured lines in the plains over the low peaks, and taking up all the stations of Capt. Robinson's topographical survey, and thus forming ample points common to the two surveys, on which the planetable sketching of the entire base of the foot of the hills was laid down with great minuteness[1].

Anderson completed his survey by the close of season 1858–9, and then moved his party down to Oudh[2] [263]. In his last season

the whole of the remainder of the plains of the Leia District, with portions of the Shahpoor District up to the Salt Range, have fallen within the operations, together with such portions of the river Indus and the Khussore Hills west of that river as were necessary to complete... connection with the surveys in the Derajat. ...

This completes the whole of the plains of the Punjab and, in due connection with the topographical survey of Jhelum and Rawulpindee by Captain Robinson, ... places us in possession of materials for the whole of the Punjab proper, or country between the five rivers[3].

BOMBAY

A full account of the organization and procedure of the revenue surveys of the Bombay Presidency has been given in volume IV of these records [IV, 235–40]. Between 1846 and 1847, survey was proceeding under the direction of Goldsmid as Revenue Commissioner at Poona. Wingate, Nash, and Davidson were Superintendents at Dhārwār, in South Marātha Country[4]—Poona and Sholāpur in the Deccan—and Nāsik in Khāndesh—respectively. Each was responsible for both survey and assessment of revenue within his division. In 1849 a start was made in Ratnagiri by moving a detachment from the S.M.C.

In 1846 the members of the Bombay Government disagreed as to the best system of control. The Governor and one of his colleagues considered that

the superintendence should be vested in the Collector of the District who, with a full complement of well selected assistants for the ordinary revenue and magisterial duties, and a few able surveyors, would...find no difficulty in conducting the duties of both offices [IV, 239]. ...

The third member disagreed and preferred a separate establishment as

in the Deccan and Southern Mahratta Country. ... Experience hitherto is...opposed to the success of a survey conducted through [the Collector], ... who can hardly...to give that undivided attention...necessary for the satisfactory execution of such an important undertaking

The Directors decided that a separate organization was essential[5].

Nash took furlough in January 1847, and was relieved by Goldsmid, and when Davidson took furlough in 1848 he was relieved by George Anderson. On relieving Nash, Goldsmid found that instead of making systematic tests of Pringle's survey and only revising those areas that were found unsatisfactory, he had been making complete re-survey of whole districts [IV, 236–9]. He made detailed surveys of uncultivated hills for purposes purely topographical, "dividing the hills into estates, and marking off the limits, ... thereby entailing a useless expense". Two of his military assistants were discharged to military duty as knowingly departing from standing instructions, and the Revenue Commissioner was blamed for having allowed this;

Of Lieutenant Nash's zeal, and of his earnest desire to do his duty, the Government was well aware, but...his mismanagement has caused a wasteful expenditure of time and money, injury to the people, discontent, and great confusion. ... Such mismanagement...could not have continued...had the Revenue Commissioner...exercised due vigilance[6].

Bombay villagers were required by law to define boundaries by permanent marks, and field boundaries by earthen ridges. Davidson reports difficulty

in getting the field boundaries ridged in consequence of the distress that prevailed through disease and scarcity. ... I refrained from having recourse to the Bombay Act in the hope that the ridges would be completed to the standard size after the monsoon. I am...able to report

[1] *GR. Rev. 1857–61* (78). [2] Penton Thompson; A. Foy; Patterson; C.W. Campbell; G.B. & W.S. Buttress, and 30 Indian surveyors. [3] *GR. Rev. 1857–62* (76–7). [4] commenced Dec., 1842. [5] BO RC. 68/1846 (66–9). [6] BO RC. 169/1847 (789–819), 30-12-47; 209/1848 (214–5), 12–5–48.

that the boundaries of the districts...are clearly defined, and ridges nearly finished. In the districts now in progress the ridging keeps pace with the measurements [IV, 429][1].

In his report for the year ending 31st October 1848 Wingate records the introduction of lithography for the revenue surveys ;

When at Poona...in the monsoon of 1847, I obtained...a large lithographic press from the... Poona College which had been transferred...on the abolition of the Surveyor General's office at the Presidency, but had never been used [IV, 327–8], and brought it...to Dharwar. ...

This press could not be brought into use from the want of lithographic stones, but on obtaining four small ones from the Government press at Bombay, I...had the satisfaction of finding it likely to answer my expectations. Since then larger stones have been obtained from England, and many hundred copies of village maps executed at a cost altogether trifling when compared with the expense of employing draughtsmen[2].

Scale of mapping varied with the size of the holdings. Whilst village maps of the Southern Marātha Country were prepared on scale of 20 *goontas*, or 200 yards, to an inch, i.e., 8 inches to a mile, in Ahmednagar the scale was sometimes as small as 2 inches to a mile[3].

At a conference at Kirkee, in 1847 the three Superintendents, Goldsmid, Wingate, and Davidson drew up rules for the future guidance of revenue surveyors [IV, 238–9][4]. During recent surveys the original records had been supplemented by

a rough sketch map, ... and it was...found possible to produce sufficiently accurate field and village maps by means of the cross staff and chain without the aid of theodolites or other instruments for measuring angles. The want of an accurate village map had been noticed by the Government of India as a marked defect, ... and by the present system we are able to furnish it. ... The village maps can be united to form a general map of a district...from Major Jopp's maps, on which the positions of the principal places are correctly given, or... from a triangulation based on the Great Trigonometrical Survey. ... These maps do not add materially to the cost of the survey, and their protraction affords a useful check [IV, 237–8]. ...

The ordinary measurements by chain and cross staff are inapplicable to...mountainous tracts where the theodolite would be required, but the two modes of survey may be combined, and there is no difficulty in instructing native surveyors in the use of the theodolite. ...

Government proclamation ordered that the boundary marks of the fields at the survey were to be carefully preserved, and at the time of ploughing an untouched strip three cubits wide should be reserved as a continuous boundary[5].

The Surveyor General saw no way of turning these Bombay revenue surveys into satisfactory topographical maps, and Dickens later commented that

the field measurements are carried on in a very detailed and laborious manner, and...supervised by European officers, chiefly from the army, who also perform the assessment which is fixed on each field. Although great care and labor are bestowed upon the original work, the correctness of the measurements is not checked by professional survey, but merely by the superintending officer himself re-measuring a portion of the work[6].

SIND

Revenue surveys in Sind had been carried on from 1843 in desultory fashion under Baker and Scott in conjunction with the Department of Canals and Forests. A few assistant surveyors had experience with the revenue surveys of the North-Western Provinces. In 1849 the Engineer officer who had succeeded Scott, Alfred De Lisle, had 8 European assistant and sub-assistant surveyors, and 12 Indian surveyors drawing from 8 to 70 rupees a month, and for January 1850, had an allotment of about Rs. 2,500. He was engaged in teaching his surveyors "the mode of triangulation laid down by Lieut. Colonel Waugh" [192–3];

The revision of the jagheer surveys and copying them into a book is now also nearly completed. Some of them are out of their true position, but that can only be corrected by work in the field. ... I might...employ some of the surveyors in the districts between Karachee and the river south of Tattah. We have not yet any good surveys of these districts. ... I should

[1] BO RC. 206/1848 6-12-47. [2] BO RC. 210/1849 (21–4), 30-3-49. [3] *IO Cat.* (421-4, 441), Rev. Svy. Bombay. [4] *Rev. Svy. (India)* (296), 2–8–47; Amended Rules, 1849; *Bo Rev Svy.* (103–6). [5] BO GO., 20–8–52; BO. Rev. Svy. (8–19); cf. Mackay (282-95). [6] Dickens (3); cf. *Roorkee Papers*, CX (184-212); Markham (193–5).

propose surveying the pergunnah and jagheer boundaries with theodolite and chain on the circuit system, as it requires fewer khalassies than triangulation and is more rapid[1].

The Bombay Government, however, decided to wait until a new survey could be organized on sound lines, and the existing staff was broken up [103];

Unless the survey be commenced de novo, and...established on a proper system, the results will be the same as on previous occasions when, after the expenditure of lacks of rupees, the only returns were either a number of detached route surveys which nobody can frame together, or a little...triangulation which, having no relation to the larger series, is useless[2].

In January 1855, the Commissioner asked for a rough survey and settlement

such as may furnish the details which will not be given by a scientific topographical survey, ... and at the same time furnish the data indispensible to a rough survey settlement. ... There is at present no complete survey...of any single district in Sind. The lithographed maps of Collectorates compiled by the Q.M.G.'s Department...have been most useful, but they are... from confessedly very incomplete data.

The boundaries of no single Collectorate are accurately laid down. Few of the purgunnah boundaries, or of the canals, are perfect. There is no attempt to mark village boundaries, and the greater portion of each collectorate is a blank. ... Few or none of the village boundaries even are marked or recorded, though all are known to the villagers. ... Inquiry and demarcation...may be best superintended by those officers who may...make preliminary revenue settlements. ... Portions of the country have been partially surveyed by Boundary Commissioners, others by the Sind Survey and Canal Department. ...

A map, as perfect as the means...will admit, should always be drawn up to illustrate the fieldbook of each village. It should at least show the relative positions of the several numbers and of the village boundary marks[3].

On further pressure the Surveyor General recommended the transfer to Sind of one of the Punjab survey parties, under charge of Robert Shortrede, a senior Bombay officer of considerable survey experience.

There must be not only a survey party under an experienced head, but also a civil establishment acquainted with the system, and unless this can be secured all the experience and training of the revenue survey party will be wasted, and it would be far better, cheaper, and more efficient, to survey Sind topographically than to attempt to introduce the Bengal Revenue Survey system under unfavourable circumstances[4].

Shortrede's appointment could not be arranged [391], but the Commissioner welcomed the transfer of the party from the Rechna *doāb* under John Macdonald ;

A revenue survey in the Punjab...is very different from what is usually called a revenue survey in this Presidency, and...very much resembles what in other countries would be called a detailed topographical survey. ... Such a revenue survey will not give the minute details obtained by the system heretofore followed in the Deccan and South Mahratta Country, but it will be more rapidly executed, and will greatly lighten the labours of the Settlement Officer. ...

If each officer were to finish a whole district in the course of each season, ... it would take 14 years...before the whole province were completed[5].

Sending a detachment under William Lane to survey a small area round Karāchi for railway purposes, Macdonald and his main party reached Rohri in Upper Sind in March 1856, too late, writes Thuillier, to carry out any survey that season ;

Demarcations were not commenced ; the Civil authorities were in entire ignorance of our requirements and the proper way to prepare the country in advance for a large professional establishment, neither were there any natives sufficiently instructed to undertake the proper demarcation. ... The entire resources of the professional party were therefore devoted to the task of instructing putwarrees and...aumeens. Twenty of the native surveyors were set to work to define the boundaries of villages in the Rohree Collectorate on the left bank of the Indus, ... all skilled in the use of the planetable, prismatic compass, and chain. ...

Another class of 80 putwarrees was formed at Sukhur. ... Subsequently two other schools were established, one of 140 pupils at Hyderabad, and another of 40 at Kurrachee. ...

The only survey of a professional character which could be attempted was a triangulation of the hills and country round Kurrachee, based on...the G.T.S. ; 307 square miles laid down on scale of half a mile to an inch. The large plan of the Town and Harbour of Kurrachee has been received, and is a very fine map, well drawn, and altogether a creditable performance[6].

[1] BO RC. 185/1850 (255–6), 11–1–50 ; De Lisle's map, *IO Cat.* (447). [2] BO RC. 185/1950 (277–9), from Mil., Bd., 31–1–50. [3] *Bo Sel.*, XVIII (9–11). [4] DDn. 665 (112), SG. to DSG. 4–10–55. [5] *Bo Sel.*, XVIII, from Comnr., 21–1–56. [6] DDn. 624 (74), DSG. to SG., 5–4–56 ; 624 (164), 1–2–57.

During season 1856–7, work was started at Rohri on the left bank of the Indus;

The whole area to be divided mouzawar [IV, 206]. ... Some small tracts of broken stony hills...have been triangulated. Nearly all the field work was done by natives. In the early part of the season I considered it unwise to march the European assistants about and later, ... when it became necessary to carry about large quantities of water in addition to supplies for the camp, the expense of moving about would have been beyond the means of any sub-assistant. ... I required 32 camels in addition to 12 for my own tents and baggage.

The gentlemen in charge of the camps were chiefly employed in superintending the office calculations, and the...copies of the general maps were all completed by their agency.

Area surveyed, 3,937 square miles at average cost of Rs. 13–12–3 per square mile. This includes all contingent charges and carriage. ... The line-cutting expenses were defrayed by the Revenue Surveyor out of his contingent allowance of Rs. 200 a month [398].

A great deal of sickness during the first two months. ... 16 men died out of 242, and from 80 to 100 always sick—fever and ague in tertian attacks, often succeeded with dysentery—and it was under the latter that most of the sufferers sank and died. It was most disheartening. The dry hot weather of March soon restored health and strength. ...

The officer in charge did a good deal of chain partalling. For the interior survey every detail was rendered, ... cultivation and fallow being classed, mapped, and measured, under one head, ... every variety of jungle, tree, bush, and grass, the waving palms and sheltering mango groves—all the features of the country in rivulets, canals, marshes, and ponds, swamp or barren waste, whether of clay, sand, or stones—all were carefully mapped and depicted.

The interior surveyor worked on plots of the traverse circuits placed on the planetable.

In my last season in the Punjab my camp was under canvas for 248 days, a period of 7 months and 28 days, but in the burning heat and pestilential exhalations of a flooded district in Upper Sind, such exposure could only be undergone by the very strongest persons, and not one of my European assistants can bear any severe exposure without immediately suffering. ...

Survey squads had occasionally to stop work through failure of supplies.

All the thakbust maps of Rohri District were available whilst the professional survey was being carried out. They were uniformly excellent, and were constructed by scales and compass on a planetable. The patwari who surveyed them was guided also by a rough compass attached to the planetables. 70% of the demarcation and thakbust maps was performed... by survey moonshees, and...no surveyor ever had better thakbust maps to guide him[1].

The *khasrah* survey of 1856–7 was directed by the Settlement Officer, Captain Henry Day, who came from the Deccan revenue survey [IV, 369], and entirely disregarded the valuable work of the professional survey.

He devoted much time and labour to do comparatively imperfectly what was subsequently done more perfectly by the trained establishment. ... Mr. Kyte, an uncovenanted surveyor trained in the Deccan survey, has completed a survey more in accordance with the Deccan practice, and has been ordered to conform with the rest of the Province[2].

After comparing them with the professional survey, and with the approval of the Commissioner, Macdonald rejected all Day's settlement measurements;

The Government of India has directed that all the revenue surveys in Sind should be conducted on uniform plan similar to that followed in the Punjab. ... I suggest that Mr. Kyte and Major Macdonald should meet Lieut. Wallace and suggest a system for essential uniformity. All Mr. Kyte's future proceedings should be in conformance with such plan[3].

Macdonald's party was now split into two, whilst four Settlement Officers were allotted to the districts under survey and settlement. Between 1856 and 1858 Lieutenant Ford was Settlement Officer in Larkhāna, for whom Kyte surveyed over 200 square miles of village details during 1856–7, his plans being "neatly and carefully drawn" and his surveyors well taught.

During season 1857–8 work lay on the right bank of the Indus, and in 1858–9 whilst Lane took a section down to Karāchi, Macdonald took up the frontier tract round Jacobābād[4]. Work commenced on 18th November 1858, only two or three weeks before the death of Brigadier Jacob "who had so earnestly desired to see the survey completed [IV, 448]".

The survey...was intended to embrace a greater minuteness of detail than is usual in purely topographical survey, but not of the usual village separate definition. Estate boundaries

[1] *Bo Sel.* XVIII, from Macdonald, 27–11–57; maps; MRIO. Misc., Rohri, Sukkur, Bukkur, 8-inch to mile. [2] *Bo Sel.* XVIII (111), from Comnr., 16–4–58. [3] ib. (88), from Comnr. 11–12–57; Wallace having relieved Day as SO. [4] *IO Cat.* (453), Jacobābād, 10 ch. to inch, Todd & Bolton, 1858–9.

where existing should be shewn, the details of cultivation and soil being fully entered into, scale 2 inches to a mile. ...

The present survey has cost less than the towers originally built by General Jacob himself to carry out a system of triangulation which was never completed. ... These towers, ... well known...as Jacob's Towers, were intended...to save line-cutting expenses but, when the Surveyor commenced, ... he found that the platforms and towers were so faulty in construction that it was in vain to expect good work [45–6, 110].

Survey was accordingly run by traverse directly based on the Great Indus Series[1].

Lane's work between Karāchi and Kotri was for the assistance of the railway engineers. The area of 2,059 square miles included only 2 miles of cultivation and 65 fit for cultivation, the population barely "2,000, all miserably poor, ... with the barest necessities, the coarsest food, and the commonest raiment"[2] [479].

Macdonald's work during 1859–60, fell in Larkhāna District. He had suffered severely in health, especially his eyes, and on 22nd April 1860, he handed over to Lane and took furlough for 15 months. During 1860–1 Lane carried out 6,190 square miles of 1-inch topographical survey in Khairpur, "mostly sandy desert, with highly cultivated alluvial lands on the river bank [100]"[3].

MADRAS

Before 1850 the Madras Government had never accepted the necessity for accurate scientific control of revenue measurements or surveys. Such surveys as were required for assessment of revenues were carried out under the district officers by Indian measurers and supervisors, on the lines of Thomas Munro's survey of the Ceded Districts [II, 180–2]. After full consideration of the systems followed in Bengal and Bombay, the Board of Revenue at Madras expressed the following views on proposals put forward by the Collector of Tinnevelly in 1842 ;

Cultivated and culturable lands are measured by natives according to the native method, and tested by controlling natives, and accurate accounts...with specifications of the boundary marks, and name and number of each field, are formed. ...

A survey carefully conducted according to the rules laid down by Sir Thomas Munro and acted on in the Ceded Districts [1804–8] will be found generally sufficient for all ordinary practical and useful purposes and if, in addition, the means of testing the accuracy of the... proceedings be afforded to the Collector, ... by placing at his disposal a small scientific surveying establishment, it will be found amply so. ... The Collector will be able...to control the native measurements, to decide on disputed points regarding it, and to satisfy the ryots. ...

This combination of revenue and scientific survey will...sufficiently approach the system of the North Western Provinces as far as it is expedient to apply it to a country already scientifically surveyed. ...

The Board recommend that Sub-Assistant McMahon...be immediately placed under the orders of the acting Collector of Tinnevelly[4].

MacMahon was, however, appointed to assist Ouchterlony on his survey of the Nīlgiri Hills [179]. He was essentially a topographical surveyor.

In 1843 Sir Henry Montgomery[5] was sent to Rājahmundry on a commission which led to the Godāvari irrigation project [I : 107]. He strongly recommended a regular survey and settlement, and from the discussions that followed Frederick Priestley was in 1853 appointed under the Board of Revenue to "an experimental scientific survey of villages in the South Arcot District"[6].

The other Presidencies were consulted, and concrete proposals were made by the Madras Government in a minute dated 14th August 1855 ;

In this Presidency alone there has hitherto been no regular survey. In all districts there is the utmost confusion in revenue matters, resulting in great loss to Government. The absence of accurate information has the most pernicious results. Not only does it operate injuriously

[1] *GR Rev. 1857–61* (126). [2] ib. *1858–61* (126-7). [3] ib. (128–9). *IO Cat.* (440); Sind Rev. Svy. 1856–72 ; 102 one-inch sheets, 13 quarter-inch, pub. @ 2 sh. each. [4] DDn. 451 (49–63), 21–1–43. [5] Sir Henry Conyngham Montgomery (1803–78), Bart. ; MCS. ; Sec. to Rev. & FW. Depts. 1845–50. [6] *IO Cat.* (391), Chidamparam *taluk*, s. Arcot, 1854–6, 1" to mile ; MRIO. 128 (12), 2-inch, litho ; *Mad Sel.*, IX (6–14); Feb. 1854.

on the public revenues, but it becomes a means by which the poorer and less influential classes are made to suffer for the benefit of the wealthy. ...

In some districts attempts were at the beginning of the century to establish something like a register of lands, and fixed rates of assessment founded on actual measurement and valuation. But these measurements were in every case carried out in haste, with imperfect agency. ...

Government are decidedly of opinion that the revenue survey should be connected by minor triangulations with the Grand Trigonometrical Survey[1]. ... A survey for revenue purposes, not a topographical survey. The size of the fields require to be accurately determined. This should be done by...the English methods of surveying as in Bombay, and as is now being done by Captain Priestley in South Arcot, and not in the inaccurate native method. ...

The detailed survey need extend only to the cultivable land. ... Jungle and unreclaimed waste need not be surveyed in detail, but only in its chief features. ... Permanent boundary marks would be established, and...field, ... village, ... and talook maps, should be prepared. ...

The Governor in Council proposes...to appoint a Surveyor General, or Superintendent of the Survey, ... to have at least four Deputy Surveyors General, each in charge of a separate ...division. ... 700 square miles may be taken as the work of a Deputy Surveyor General's party; ... cost should be about Rs. 64 per square mile, and the survey occupy 22 years.

Classification of land should be entrusted to...a Superindent of Settlements, ... vested with a general power of control, ... but not interfering in the mode of working[2].

Priestley was appointed Superintendent of Survey from August 1857[3];

The area to be surveyed was computed at...79,411 square miles for topographical work, and 61,617...for revenue work. Captain Priestley commenced work with an establishment...of 18 surveyors and deputy surveyors, 30 survey ameens, 30 gumashtas [II, 181], 20 draftsmen and computers, 77 peons and measurers, and 19 station markers, at an annual cost of Rs. 31,338. Mr. Nevill was appointed Superintendent of the new revenue assessment, and the two officers worked in concert.

In 1857 two talooks, one in South Arcot and the other in Trichinopoly, were surveyed. In 1858 the survey was commenced in the Rajahmundry District. In 1859 Masulipatam was taken up, and in 1860 there were parties in Nellore, Trichinopoly, and Salem.

During season 1856-7 Priestley had surveyed 450 square miles in South Arcot, and increased this to 476 the following season. Scales of survey varied from 4 to 12 inches to the mile [8][4]. During his absence for several months organizing the new department, he left William Hessey in charge[5].

In 1859 a survey was undertaken of the...district of Wynaud...to define the boundaries of the coffee estates. ... The district had been surveyed topographically...in 1826 by Lieutenants Garling and Conner, ... but the sites of villages were not accurately laid down [III, 114]. ... Work was commenced in 1860 with a system of secondary triangulation...the detail being filled in by planetable[6]. In 1861 and 1862, the Neilgherry and Coondah Hills were surveyed [III, 111-3; V, 179-80]. A lithographic Press...was...established at Madras for...publication of talook and village maps[7].

In 1859 Priestley had a staff of three military officers, Hessey, Pratt, and Crewe, and six civilians, Leggatt, Durnsford, Beaumont, Cardozo, Puckle, and Wright.

In 1870 Markham describes the Madras Revenue Survey as one in which the survey and revenue officers work together, and which is conducted on correct principles in every detail, in the field measurements as well as in the village boundaries, with a complete series of tests. ... The Madras Revenue system alone answers this description, and must consequently be considered as the best. Its work is adapted to reduction for geographical purposes, being carefully connected with...the G.T.S. ...

The revenue survey is complete in the Godavery, Kistna, Nellore, Trichinopoly, and Salem Districts, and the topographical survey of the zemindary, or rent-free lands is in progress in Nellore and Salem. In Kurnool and Tinnevelly the revenue survey is approaching completion, and it is progressing in Cuddapah, Coimbator, Chengalpat, Ganjam, and the Nilgiris. In Wynaad 124 square miles of estates were surveyed before...1862[8].

Neither the Madras nor the Bombay revenue surveys ever came under the administration of the Surveyor General of India.

[1] strongly urged by Henry Thuillier, DSG. [2] *Mad. Sel.* LVII (2-39), CD to M., 17-12-56. [3] from 18-8-57; Markham (189). [4] Godavari Dist., 1859-60, Crewe with Wright & Cardozo; MRIO. 14 (110); *IO Cat.* (329). [5] *Mad. Sel.*, LXXIV, Report 1857-8 (38-52); 16-11-58. [6] 1859-6, *IO Cat.* (314), 1" *taluk* maps. [7] *Madras Admin.*, I, 1885 (99). [8] Markham (180, 188-93); Maps of Mad. Rev. Svy., 1871; *IO Cat.* (314-7); MRIO. 128-130.

CHAPTER XVIII

PROFESSIONAL DETAILS: TOPO. & REVENUE SURVEYS

TOPOGRAPHICAL: *General Instructions — Manual of Surveying — Revenue Surveyors — Triangulation — Traverse Survey — Planetable Survey — Computing & Mapping* — BENGAL REVENUE SURVEYS — *Connection with G.T.S. — Traverse Control — Instruments — Demarcation of Boundaries — Field Survey or* khasrah — *Units of Measure — Field Tests — Faulty Work — Maps.*

JUST as it had been Everest's mission to establish the work of the Great Trigonometrical Survey on high scientific principles, so it fell to Waugh, his successor, to lead his surveyors to a high standard of topographical survey and mapping, worthy of Everest's incomparable framework. Thanks to the dogged insistence of Blacker and Everest and the powerful support of William Bentinck, the Court of Directors had wisely decided that no surveys should be accepted for the quarter-inch Atlas of India that were not surely based upon the Great Trigonometrical Survey. Gone were the days of perambulator traverse, astronomical latitudes, longitudes from Jupiter's satellites, chain-measured base-lines, and isolated patches of triangulation [III, 195–6 ; IV, 19, 261].

Whilst the Madras parties followed the methodical system taught by Mackenzie, filling in or extending Lambton's "grand triangles", the Bengal revenue surveyors worked in plains that the triangles had not yet reached. They filled in topographical details by the same traverse circuits and bearings that they used for their fiscal boundaries, but none of their work was accepted for the Atlas until it had been adjusted to the Great Trigonometrical Survey [IV, 288–90 ; V, 295–6].

Waugh's training had lain with the trigonometrical survey, the measurement of base-lines, the lay-out and observation of principal triangles, and high-class astronomical observations. His first contacts with topographical survey, and the need of instructions for inexperienced officers, came in 1844 with Ouchterlony's survey in the Nilgiri Hills[1], and Scott's survey of Sind [179, 192]. In these instructions he dealt first with the provision of primary control. Then followed

> minor triangles...covering the areas of the principal triangles...fixing limits to inaccuracy...a few miles asunder. Topographical details depending on the...triangles carried on—either with the planetable as in the Madras surveys—or with the theodolite and chain—or with the perambulator and theodolite—according to the degree of accuracy which local circumstances render desirable. A process...such as this is essentially necessary in any country of which we intend to retain possession. All else is but patchwork, and expedients for the hour, which will never satisfy expectation nor supersede the necessity of future revision[2].

He writes to the Chief Engineer at Bombay [191–2];

> The orders of the Hon'ble Court of Directors are that no district which has been once surveyed should be revised until every part of India has been surveyed. This...is a sound rule...admitting...of few exceptions. ...
>
> The Trigonometrical Survey having been debarred...from taking up detail [IV, 14], the organization of the parties has been strictly regulated for...furnishing fixed points of reference. ... The general triangulation of a large country must be performed by distinct parties specially trained and confined to that duty alone. ... The triangulation done by topographical surveyors has been, and will always be, of the most inferior kind, unsystematic, and liable...to accumulate immense errors [285–6]. On the other hand, the scrupulous care, the horror of minute errors, the refinement in observation and calculation to which a geodesist must be trained before he is worth his salt, is perfectly thrown away in detail surveying. ...

[1] DDn. 491 (110½) SG. to Ouchterlony, 4–10–44. [2] ib. (150–69), to Scott, 3–3–45 (52 paras).

The topographical surveys are no doubt susceptible of much improvement in accuracy but not without a corresponding increase of expenditure and time. The expense of the revenue survey in Bengal averages about Rs. 15 per square mile. ... These surveys fulfil all that is required for revenue purposes but, as the measurement of boundaries is the chief object, their value as topographical surveys is not equal to that of surveys in which topography is the primary object. Nevertheless these surveys, provided the country be level and open, answer very well, after due incorporation with the trigonometrical survey, as materials for filling up [309]. ...

No satisfactory improvement can be made in the internal filling-up surveys unless they are preceded by the Great Trigonometrical Survey. ... Any separate local triangulation cannot supply the place. ... By reversing the proper order, ... a great deal of work has to be done twice over, and everything is unsystematic, confused, and unsatisfactory [295][1].

By 1852 Waugh's attention was perforce drawn to the technical details of plane-table survey by his desire to improve the work of Du Vernet's party in the Himālaya and of Saxton's in Orissa. He was, moreover, determined that the new survey being started under Robinson in the Punjab should reach the highest possible standard of accuracy, and give a faithful representation of the ground. The staff should be thoroughly trained in sound technical detail, and their work organized and supervised by an officer who should be a complete master of topography.

With this view he drew up *Instructions for Topographical Surveying*[2] which, at the request of Thomason now Lieutenant Governor of the North-Western Provinces, was in 1853 printed and published at the Engineering College, Roorkee, and issued in June 1854[3] [211, 338].

The paper originated in my having to write instructions for the Bombay Presidency and, being designed for the use of officers with whom I had no previous intercourse, ... I had to enter into more minutiæ than would otherwise have been requisite[4].

Amongst points from these *Instructions* Waugh writes ;

The term Topographical Survey implies the measurement and delineation of the natural features of a country and the works of man thereon, with the object of producing a complete and accurate map, free from the trammels of boundaries and properties. ...

Break down long sides of the Great Trigonometrical Survey by ray-trace triangulation, ... and with suitable network of triangulation cover the area...with fixed points 3 to 5 miles asunder. Spherical excess of the large triangles must be dispersed, and computations computed for latitudes, ... longitudes, and...azimuths...based on a spheroidal surface of the earth [133].

Points are then plotted on a board. ... Flags or other marks should be set up at those points where the planetable is to be fixed. Such...positions being fixed...from the trigonometrical stations render the survey independent of the magnetic needle. ...

In ground unsuitable for the planetable the area of the triangle may be measured up by chain...or...filled in by traverse run from one trigonometrical point to another, taking offsets.

On a scale of one inch to a mile a district can be completely surveyed by means of the planetable at a cost of 6 to 8 rupees a square mile, including...minor triangulation. On this scale all those objects should be delineated which are essential...for political and military purposes. The scale of ½ an inch per mile is to be resorted to...in very dense jungle countries [289]. ... On the scale of one mile per inch a practised draughtsman can execute about 5 square miles per diem, while on the ½-inch scale 16 square miles may be accomplished, in each case supposing the detail to be minutely drawn and nothing omitted which the scale admits of [289–90]. ...

The rate of six rupees per square mile...is derived from the Hyderabad survey. ... Elevations...if...extended to all obligatory points for roads, drainage, and canals, will considerably enhance the cost [68]. ... On a scale of one mile per inch the general figure and extent of cultivation and waste and forest tracts can be delineated with more or less precision[5].

In 1854, Waugh sent a copy of these *Instructions* to Williams, of the Pegu Survey, with a long letter and various manuscript notes [195, 285] ;

All my instructions for...trigonometrical surveys...are in manuscript. ... I can only refer you therefore to the chapters on trigonometrical surveying in the Manual [Thuillier & Smyth], which are based on the instructions I issued to Captain Ouchterlony of the Madras Engineers in 1844. These...were found sufficient in the case of Lt. Walker's survey of the Peshawar frontier [215], the results of which have fully satisfied expectation and have been incorporated

[1] DDn. 543 (53), SG. to CE. Bombay, 15–5–50. [2] cf. his *Instructions for a Trigonometrical Survey* [98, 117, 179, 286, 338]. [3] 2nd edn., Roorkee, 1861 ; v. Thuillier & Smyth, 2nd. & 3rd. edns. (appx.).
[4] DDn. 591 (232), SG. to Robinson 28–8–52. [5] *Topo. Instns.* (paras 3, 38–46).

with facility. This has not been the case with other independent surveys. ...
[and later]—Although a map on the scale of 4 miles to 1 inch is considered sufficient for present purposes, I...recommend that the details should be taken up on the half-inch scale, because the progress in one case will be as great as the other on account of the freedom of sketching and plotting on the half-mile scale, and more particularly of printing the names. On the ½-inch scale the details usually represented are so crowded and such fine printing is required that it is not a suitable scale for working in the field [289][1].

He considered that a proposal made by Saxton for a four-inch planetable survey of the Mahānadi delta showed an error in principle and
cannot produce a satisfactory result. The planetable is an instrument for sketching in topographical details upon a basis of triangulation. No survey of even moderate extent can be executed by the planetable alone with any pretension to accuracy. Possibly with great care each planetable section might be done without much inaccuracy within itself, but two tables could not be combined, far less several, into a general plan, ... nor could the work be susceptible of incorporation with other work, or of further extension. ...

The planetable is a good servant but a bad master, and without an accurate preliminary triangulation his planetable sketches of rivers would be so much waste paper. ... A preliminary triangulation...is indispensable, and the points must be computed and projected upon the boards before the latter can be used. ...

The idea in Captain Saxton's mind appears to be a sketch along both banks of a single river, but a delta is not a single river. ... A survey of a delta would lose much of its value for public works if all the branches and creeks were not included in a congregated map.

Men accustomed to survey geographically on a half-inch scale will find a four-inch scale very different, requiring qualifications of another order, and some practice and experience[2].

Waugh rebuked Du Vernet for suggesting that the upper ranges of Chamba might present " insurmountable " obstacles to his surveyors [204–5]. He agreed on another occasion that it had been wrong to mark as "impenetrable" certain areas in the rough jungle-covered hills on the eastern borders of Kurnool that had been left unsurveyed by Mackenzie's surveyors of 1810–2 [II, 153–5 ; V, pl. 28] ;

"Impenetrable"...no doubt is bad English in the same sense that Napoleon said "impossible" was bad French. ... The designation... could be considered highly incorrect. Neither the Himalayan snows, nor arid deserts, nor dense unhealthy jungle, nor hostilities, nor any other impediments, have been allowed to arrest the progress of surveys in our time, and the hiatus in the Kistna [map] could be filled up, no doubt, ... if proper arrangements are made [t-page].

"I have waded through the Madras records of those days. ... There is nothing...to show why this tract was left unsurveyed. Although no tract can in correct language be denominated 'unpenetrable to survey'...adequate means are indispenable for success. ... That the Madras surveyors were in those days badly equipped for contending with a wild forest tract I have had occasion to represent, and...Captain Saxton's establishment was remodelled to enable it to surmount similar difficulties. Each assistant surveyor was allowed 3 khalasis, and nothing can be conceived...more hopeless than so inadequate an establishment when in the midst of a wilderness of thorny bamboo [III, 395 ; V, 455]. ...

All that is necessary is time and means. I can only surmise, therefore, that the surveyors of those days—finding themselves insufficiently equipped—left this tract unsurveyed, considering it worthless to be undertaken while so much more valuable accessible country remained for survey[3] [III, 286].

Manual of Surveying for India

The first edition of the *Manual of Surveying*[4] was published by Thacker in Calcutta in 1851 at Rs. 16 a copy. It was mainly the work of Ralph Smyth, and was prepared primarily for the use of revenue surveyors. Whilst in charge of the revenue survey of the 24-Parganas District, he reports from Dum Dum that " the Treatise on Surveying...is about half completed; i.e., ... about half is already printed and...I anticipate its entire completion in about 3 months". There had

[1] DDn. 592 (13, 81), 18–2 & 6–7–54. [2] DDn. 474 (2), SG. to DSG., 21–1–58. [3] DDn. 665 (37–9), SG. to DSG., 5–9–54. [4] here quoted as 'Thuillier & Smyth'.

been " difficulties of progress, ... to say nothing of my being enabled to devote only my leisure hours from office to it"[1].

In May 1850, Thuillier, to whose initiative and guidance the work was largely due, sent up to the Surveyor General an advance copy containing the 450 pages already printed, with most of the plates and diagrams.

The two first parts are compilations and elementary. Mr. Thomason [IV, 471 ; V, 282] wants a translation or vernacular abstract...for the...Roorkee College. Part 3, up to chapter 21, on professional matters, speaks for itself—full of faults I fully expect—but it has cost some labour to get through the press. Radanath has done much in the trigonometrical chapters 15 to 21. They are almost entirely his own, and will be duly acknowledged. ...

[It has benefited] greatly by all that you have written...as you will plainly see. In fact there is nothing original in the whole volume. If the collection...makes a useful guide to beginners...I hope it may be the means of instilling ideas of accuracy. ... The diagrams caused infinite trouble and delay, this mode of printing and lithographing combined being quite new in this country, but I think the appearance...will be good, whatever may be the value of the contents [IV, pls. 8 , 10, 12]. Smyth's duties...have prevented him attending to it of late, and I am only able to lend my assistance by working at night by snatches when current business permits. ... We are using our utmost endeavours to bring it out[2].

Special acknowledgement was made to the help given by the Chief Computer, Babu Radhanath Sickdhar, ... whose intimate acquaintance with the rigorous forms and modes of procedure...on the G.T.S., and great acquirements and knowledge of scientific subjects generally, render his aid particularly valuable. The chapters 15 and 17 up to 21, inclusive, and 26 of part III, and the whole of part V, are entirely his own[3].

In circulating a prospectus the Surveyor General recommended that every officer and assistant of the Department should purchase his own copy though an official copy would be issued to each unit[4].

There are many valuable works which treat of the principles of Geodesy, and a few of its practice. There are also many works on land surveying on the small scale, and others on the use of instruments, but this Manual is the only book which embraces all these subjects, and treats of Surveying on the great scale, with all details, forms, and results[5].

A 2nd edition was published in London in 1856, and included a copy of Waugh's *Topographical Instructions*, and several other professional papers [282 n.3]. A 3rd edition, even further enlarged, followed in 1875.

The cover of both 1st and 2nd editions carries Sherwill's delightful sketch of a Revenue Surveyor observing through a theodolite under the shelter of the ubiquitous umbrella, the sketch of the 1st edition being less elaborate [III, 345]. The frontispiece of the 1st edition gives his rough sketch of six *khalāsis*, [IV, pl. 18], which is replaced in 2nd edition by a more formal plate shewing seven figures with a buff background, and entitled "Surveying in India".

REVENUE SURVEYORS

It had been ruled from the first start of revenue surveys in the Upper Provinces in 1822 [III, 158–9] that revenue surveyors should base their work on triangulation and include all topographical features as well as the fiscal boundaries required for the revenue settlements. Topographical maps were to be prepared from their work so that a second survey would be unnecessary. In hill areas such as Mirzāpur [IV, pl. 14] the character of the survey became more topographical than fiscal, and it was often a problem of debate whether to entrust the survey to the revenue or topographical surveyor, or to employ both [184, 211–2]. In the case of Robinson's survey of Rāwalpindi District, falling in the Sind–Sāgar *doāb* [274], the Surveyor General discusses this subject ;

No surveyor, however skilful, could produce a general map of Jhelum and Rawal Pindi from details sketched on the 4-inch village maps. ... No surveyor who knew his business would set about work in this manner. ... To produce a successful general map, it must be

[1] DLR. 39/68 (317), to DSG., 23–7–49. [2] DDn. 474 (285), DSG. to SG. 9–5–50. [3] surVrs. charged ½-price, DDn. 591 (106), 7–10–51. [4] DDn. 557 (144), from SG., 1851. [5] Thuillier & Smyth (viii).

taken up in the field by skilful field draftsmen on a proper scale. ... In whatever manner a revenue survey may be executed, whether on trigonometrical principles or traverse survey, no operation on a scale of 4 inches to the mile can supersede the necessity, in a country such as we are now discussing, for the actual survey from nature on the one-inch scale. ...

Whenever the topographical features...are so simple...as to be readily intelligible on the village survey scale, viz., 4 inches to the mile, so that a reduced general map can be compiled from the enlarged details, then separate topographical operations...would be an unnecessary expense. ... When the ground is uneven, hilly, rugged, and intricate, it is vain to expect that...a revenue survey can...produce a good general map. A second survey...for general topographical purposes becomes indispensable, ... whether...as an extra undertaking by the Revenue Survey party or by special topographical operations[1].

He asked the Chief Commissioner at Lahore whether the boundaries could be settled and demarcated for survey and incorporation into Robinson's map [211];

The topographical survey on the Coromandel Coast conducted...by Captain Saxton is precisely similar. ... Captain Saxton measures up all talooques, estates, and fiscal divisions, and...appears fully to satisfy...the civil authorities. To enable him to carry out these objects he is invested with the powers of Assistant Commissioner, and settles the boundaries as he proceeds [170]. ... Other topographical surveys such as Hyderabad, the Himalaya Mountains, &c., have also shewn boundaries. ...

Lieut. Robinson was instructed...to include...the boundaries of all...important fiscal divisions, provided they were finally fixed; ... provided also the divisions could be...represented without obliterating or obscuring the configuration of the ground. ... But there were none to take up. ... The divisions were all indefinite, and extensive changes were expected. ...

Accurate and faithful delineation of ground is...indispensable for many purposes. For designing and projecting engineering work it is of great value. ... For military purposes a faithful representation of ground...is an indispensable requirement, and...on a line of country of peculiar military importance of accurate topography is of special value.

In the revenue survey...the delineation of ground is necessarily subordinate to other objects of great fiscal importance. ... Flat ground is the natural sphere of the revenue survey. ...

Although Lieut. Robinson's survey can define the boundaries of the divisions named, ... I think it highly inexpedient that his party should be employed in that way[2].

No separate revenue survey was taken up, but whilst Robinson could not survey undefined boundaries, his maps were of great service for revenue administration [212, 318]. For the Derajāt beyond the Indus a detachment from Shortrede's revenue survey party, made a small-scale topographical survey of the greater part with large-scale revenue survey only where specially required [217–8].

TRIANGULATION

It had long been the practice in topographical parties for the officer in charge himself to carry out all the triangulation, keeping one of his junior assistants with him to assist in fixing signals, recording, and computing [211]. There were no established rules as in the Great Trigonometrical Survey, and the Surveyor General found much to criticise when the angle-books of the Hyderābād party were sent up for his inspection in 1844;

I have directed that they should be returned to you immediately, ... and...you will make the necessary corrections and alterations. ... Each separate document should bear the signature of the party in charge of the survey, as well as the initials of two individuals at the foot of each page in attestation of its having undergone careful comparison and computation. ...

The papers should in future be prepared in duplicate, whereof the original copy will be transmitted by me to the Court of Directors. ...

— Your angle-books are perfectly incomprehensible. Not a soul in my office can understand them. Angle-books and field-books are worthless unless they are so clear...as to be capable of being understood...by anyone. ... You will...prefix to it an explanatory memo of the meaning of the several columns, and describe the principles upon which the angles are deduced[3].

The instructions sent out to Ouchterlony—Scott—the Chief Engineer, Bombay—and to Williams in Pegu, included much that already been laid down by Everest

[1] DDn. 713 (92), 21–6–55. [2] DDn. 713 (73), 22–4–55. [3] DDn. 491 (15–7), to Chamarett 28–3–44.

in rules for secondary and minor triangulation [IV, 108], and were later embodied in Waugh's own *Instructions for Trigonometrical Surveys* first issued as a circular letter, and later published in Roorkee *Professional Papers* [117, 282 n.2][1]. Sending a copy to Walker at Peshāwar he advised him to act on the principles laid down and to adopt a style of procedure that will amalgamate with the present state of your work, and suit the means at your disposal. ... The instructions...enter fully into the mode of conducting the higher order of geodetical operations, but when small instruments are used...it would be needless to carry out the system of rigorous computation involving probabilities of error, spherical excess, and reduction of compound triangles. ...

Too much attention cannot be paid to the rules of symmetry which are even more important when instruments of small power are used. ... Every station should be carefully marked, and attention be paid to the signals being carefully adjusted to the mark.

If your instrument will reverse in altitude, I would advert to the advantage of using it alternately 'face right' and 'face left', as a sure and simple means of eliminating all instrumental errors arising from collimation and bias of axis[2].

He was anxious that triangulation in the high Himālaya should not depart from principle more than necessary, and he writes to Du Vernet ;

I have seen Mr. Keelan's rough plan of his triangulation and likewise Mr. Mulheran's. Both contain so many unsymmetrical and small triangles as well as supplemental stations that there is reasonable ground for apprehending considerable accumulation of error, to which all series of so great a length are liable when trigonometrical rules are departed from.

I do not express this criticism with the view of detracting from the merit of the individuals employed, ... whose labours...entitle them to all due credit. ... Still, ... where the conditions requisite to ensure accuracy are not carried out, errors will be generated and accumulation of error must be expected [t-page]. ... It would have been consistent with scientific principles to have checked...angular error by observations for azimuth. ... A few observations on the Pole Star at a single elongation would have been sufficient. ... Observations for latitude would have been advantageous [130, 204].

I should...feel extremely anxious to learn what discrepancies are exhibited by the junction of the two series at the Bara Lacha Pass [202]. ... It is...fortunate..,that I provided...for this enterprise 14-inch theodolites of suitable power and accuracy, for if 12-inch theodolites had been used, the results...would have been liable to great errors[3] [157].

A check on this triangulation was provided several years later by the Kashmir triangulators whose values had been brought up from principal triangles in the neighbourhood of Jammu, over the Pir Panjāl, across the Kashmir valley and the Deosai plains to the Indus, up the confines of that river to Leh, and then by minor triangulation across the uplands of Rupshu [pl. 6]. Montgomerie claims that the junction...between the Kashmir Series and the North-West Himalaya...in the neighbourhood of the Bara Lacha Pass gives every confidence in...the Kashmir Series. The accuracy indeed is remarkable, bearing in mind that the junction made is between a 1st class secondary series of the Kashmir Series and a 2nd class secondary series of the N.W. Himalaya...after a total circuit of 890 miles, of which 495 miles belong to the Kashmir Series. ...

Bara Lacha H.S. No. 1, discrepancy—Lat. 0″·82—Long. 0″·11—Height 3′·5.
Bara Lacha H.S. No. 2, discrepancy—Lat. 0″·79—Long. 0″·09—Height 6′·3.

The side Bara Lacha H.S. No. 1 to No. 2, ... height discrepancy 1·4 ft.

That is, in a total circuits of about 890 miles...there is only a discrepancy of eight-tenths of a second in latitude, and one-tenth of a second in longitude, and a difference of one and four-tenths feet in a side of 2·09 miles and 4 and nine-tenths feet in the heights of peaks after...890 miles across mountains of every altitude...from the plains up to 20,000 feet[4] [234].

This is indeed remarkable testimony to the high standard of work, even remembering Everest's caution against fortuitous agreements [IV, t-page, 17]. These discrepancies, however, came from definite chains of triangles, and it is unlikely that the haphazard networks laid out by topographical surveyors with the sole view of providing points for planetablers approached such precision.

Robinson describes the triangulation carried out for his survey of Jhelum and Rāwalpindi. He broke out from the principal triangles of the North-West Himālaya series, and started by running a line of main triangles ;

[1] *Roorkee Papers* (IV) ; Waugh Mss., II, 6–8–56. [2] DDn. 591 (29), 8–5–51. [3] ib. (138,) 7–11–51.
[4] DDn. 51 (88), Report, 1861.

The first section containing 42 triangles...was measured with an old 12-inch theodolite. ... Observations had been taken on four zeros and were frequently repeated to obtain good results.

The second section of 21 triangles consists of a chain...emanating from...the Great Indus series, and closing on a connected side of the first section, and on this chain a network has been built of the triangulation carried beyond the river Jhelum. These...were measured with a 14-inch theodolite, FL/FR. repeated. The results are remarkably accurate.

The third section of 27 triangles is based on the...Great Indus Series. ... They have been observed almost entirely with a 14-inch theodolite, simply FL/FR. the results thus obtained being definitely good for the purpose. ...

Heights have been observed at the time of minimum refraction, between 2·30 and 3·30 p.m., FL/FR. direct and FL/FR. reverse. The heliotrope was almost invariably raised to the same height as...the telescope of the theodolite, which...greatly simplifies the computations. ...

SECONDARY OBSERVATIONS. First Class Secondary Triangles. 4667 in number. The three angles of these triangles have been almost invariably observed, and they further check each other by comparison of common sides. They have been...measured with 14-inch, 12-inch, 7-inch, and 5-inch theodolites, on two to four zeros according to their importance and the quality of the instrument employed. The latitudes and longitudes...have been derived in the same way as the principal latitudes and longitudes, but only using two terms of the formulæ. The heights have been computed rigorously.

Second Class Secondary Triangles, 2213 in number. In these two angles only have been observed, ... Second-class secondary heights have been observed between the hours of noon and four p.m.—Simply FL/FR.

Staff Observations. In order to see the crests of passes, lowest points of watersheds, and other obligatory points, it has generally been necessary to throw out a station...to command a view of them. ... The height of the obligatory points have generally been determined by... observations taken to the ends of a vertical staff of known length, though in some cases a measured base has been used [72][1].

When the Surveyor General visited Robinson during his first field season, October 1851, he found that triangular errors were often larger than permissible and that theodolite stands were rickety. He ordered that triangles with exceptionally large errors should be re-observed, though

it would not answer to retrograde frequently...in the attempt to approach an unattainable perfection. ... Vernier instruments...are liable to deteriorate in a way micrometer instruments are exempt from. ... If heliotropes are employed, platforms built, ... a higher standard is attainable. ... When observations are faithfully made and truly recorded compensation takes place to a certain extent. ... A long series of triangles may come out with small errors until all of a sudden a triangle may exhibit a large discrepancy. ...

When opake objects are observed in hilly countries the liability to error will be a little more. ... In flat countries where the rays graze...larger errors may occasionally be expected, and to the extent of 25″ would not be very surprising[2].

Waugh had vast experience as a triangulator, and was apt to be scornful when difficulties were exaggerated. He writes to Brown on the Hyderābād Survey ;

In the Dekhan I have taken observations from hills during every month of the year. ... The explanation...that mists prevented morning observations, while the agitation produced by vapours during mid-day interfered with observations, ... is...ordinary interruption to which every observer is constantly exposed, and which forms no just grounds for not taking the field. ... Mid-day is invariably unfavourable for viewing distant objects, and the mornings are also more or less unfavourable, the exceptions being rare. If one were to wait for a season when morning, noon, and afternoon were all favourable...such a day would not happen once in many years. Clear afternoons may generally be reckoned on, and when clear mornings also occur, an observer should feel doubly thankful[3].

It is to this day the practice in wooded hills to leave a solitary tree standing near a hill station as mark for the planetabler, and Montgomerie suggests this to Basevi for his triangulation down the Jhelum [228] ;

The signals...should in ordinary cases consist of the usual pole and pile, and the flagmen should be instructed to make the latter as large as possible. ... When the hills are wooded, if the trees are not numerous all the trees near the top...should be cut down with the exception of the highest, which should be stripped of its branches for 20 to 30 feet, and used as a station mark. A tree standing by itself on a hill forms a better mark than anything else.

[1] DDn. 714 (203). [2] DDn. 713 (12), 24-10-51. [3] DDn. 529 (2), 21-2-49.

... If the trees are numerous, a flag should be put on a conspicuous tree, care being taken to mark the said tree with a deep triangular mark, or in such a manner as...to be easily recognized[1]

TRAVERSE SURVEY

Topographical surveyors had sometimes to traverse by theodolite and perambulator when surveying roads or boundaries, or through flat ground. In approving the survey of the Sambalpur road by Saxton's party the Surveyor General called attention to the *Manual of Surveying* ;

The distance should be measured with 3 perambulators set to read differently in order to prevent blunders. The angular observations should be taken with a good 5 or 6-inch theodolite and, being carefully recorded in the fieldbook with the perambulator readings and observations to objects off the road, the whole work can be accurately calculated afterwards by 2 computers. ... A road survey thus executed is a trustworthy scientific operation, and I...am aware that formerly on the Ganjam Survey very rough and loose methods were followed which your sub-assistants must unlearn [169].

The surveyor will...protract the route on his planetable which he will set up at each station to sketch in...the country. But, as a mere protraction cannot be depended on, especially when executed in the field, the planetable sketches ought merely to serve as materials for filling up the final map after the traverse has been done in the office from compound co-ordinates[2].

PLANETABLE SURVEY

The planetable had come into use in India so early as 1792 when it was used by Alexander Read in his survey of Bāramahāl [I : 193]. Its use was regularly taught at the Madras Institution and gradually adopted by all the Madras parties [II, 125–6, 228–9 ; III, 206–9]. Everest not only recognized it as the standard instrument for topographical surveys, but encouraged his triangulators to use it for sketching in the main features of the country [IV, 61–2]. He worked out with Mohsin Husain detailed specifications for a standard pattern of planetable, and issued exact instructions for its mounting and manipulation [IV, 147].

Waugh drew up a technical paper on the use of the planetable for topographical survey[3] and in 1850 writes to Nicolson on the North Parasnāth series[4] [15–6, 120] ;

Although I...applaud your desire to make your operations more useful by the...employment of this accurate mode of surveying the features of the ground, ... I do not think there are any planetables in store at Calcutta or, if there are, the pattern is most likely to be flimsy.

You can make up a table yourself in a few days for less money than the cost of transport from Calcutta. At Monghyr wood and workmen are plentiful. Any fine-grained, light, but firm, wood, not given to warping, will answer. I send you my design which is the kind we use here. The table is adapted to a trussed stand similar to the 12-inch theodolite stand, which we use for all theodolites from 5-inch upwards.

He continued with instructions for mounting the board and starting the survey ;

First lay a smooth piece of paper on the board to prevent the colour of the wood straining through. Then wet a piece of longcloth—stretch it over the board and turn it over the edges—fixing it on the under side with glue or paste, and let it dry in the shade. Next wet the paper, and spread the poisoned paste[5]. ... Place the paper on the table, pressing it down first at the centre, and gradually towards the edges, taking care that no air bubbles are left. Turn the edges of the paper over the board and paste below.

The trigonometrical points must now be carefully plotted...on a scale of not less than two inches per mile. The table must then be set up at a principal station, and the sight rule being laid on a principal side, the table should be turned round till the sight intersects the corresponding distant station, and then clamp tight. Having...set and proved the table, take...any compass needle in a box, and lay it on the table at any spare corner. Draw the outline of the box carefully with a pencil. This will serve at all times to set the table...by the needle.

[1] DDn. 716 (165), 5–9–57. [2] DDn. 586 (17), SG. to Saxton, 3–10–51. [3] Waugh MS. II (ix) ; OBO. Comp. M-9-2/I ; cf. Thuillier & Smyth (appx. xvii–xviii). [4] DDn. 493 (354) 30–9–50. [5] copper sulphate to discourage insects.

He describes the method of sketching and of fixing position by interpolation from three known points; "If the three rays do not meet exactly, the table can be shifted little by little till the rays prove"; the *Manual of Surveying* gives full instructions and diagrams for solving this "three-point problem"[1] [II, 229; V, 297]. He continues;

To draw hills you must first sketch the ridge, and next the watercourses. ... These lines define the character of the ground. The spurs or underfeatures between the watercourses can then easily be drawn as far as the scale will admit. ... The accuracy of the work depends on the frequency with which the table is put up, and the shortness of the distances depending on the eye. A skilful draftsman can draw 16 square miles a day on the scale of ¼ an inch per mile, ... but that quantity can only be attained by practice [282, 290].

Waugh elaborated his instructions to Robinson, whom he regarded as his chief instructor in topographical survey [211, 387–8]. His work was to be distributed by sections according with the meridians and parallels of whole and quarter degrees, so that the work may fit. Towards the margin of the district a section may have very little work in it. ... Thus the detail field-book...will consist of original field sections, each being a folio of uniform size—¼-degree in length and breadth. ... When the survey is finished these folios... each containing a field section, will be neatly bound into a portfolio with a preface and index[2]. Robinson's note on planetable survey held its place in the Departmental handbook for the next seventy years[3].

Whilst Waugh favoured the one-inch scale for well populated and important areas he obtained authority for the ½-inch scale for jungly, unhealthy tracts [282];

In...wild hilly tracts the half-inch scale is...amply sufficient...for topographical purposes. When revenue calculations are wanted, the scale must be four inches per mile, but in such districts...all the objects of the Revenue Survey can be attained by separate field measurements, and it would be a needless expense and waste of time to take up the topographical delineation of large tracts of hill and forest on the same scale as field measurements[4].

He rejected Saxton's proposal for field survey on the ¼-inch scale;

All former surveys in the Madras Presidency are on a scale of 1-inch per mile, and are highly admired for their topographical value. One inch per mile is the proper scale for planetable work of any high pretensions. ... The Hon'ble Court of Directors have sanctioned a half-inch scale for wild jungly tracts with a sparse population and little cultivation. Such parts are generally unhealthy, and it is desirable to accelerate the progress of the work. ... This therefore is the authorized scale for your survey.

The ¼-inch scale is...too small for...work in the field as it allows no freedom in drawing, cramps the hand, gives a meagre representation, and affords no room for names of localities without obliterating the features...altogether. ... Drawing in the field can be done quite as rapidly on the half-inch scale. ... The ¼-inch scale reduction is required for the General Atlas, and can be executed with due care in quarters, producing a more elaborate and correct map than if the work had been at first executed on that scale in the field[5] [214, 290].

For the Pindi survey he preferred the one-inch scale;

Its character as regards ravines could not be done justice to on a smaller scale. ... I do not think...the one-inch scale would progress very much slower than the half-inch, for all the hill work is massive, and nearly as easily drawn on one scale as the other, while there would be much more freedom in drawing the ravines [214][6].

There was no standard rule for spacing the triangulated points required by the planetabler; it depended on the scale and nature of the ground [119, 210, 220, 231].

As regards cost [189] Saxton estimated that the ½-inch survey cost 7 to 8 rupees a square mile compared with 9 to 10 rupees for the one-inch. The Surveyor General advised the A.G.G., Central India in 1855 that

I have estimated in my printed Topographical Instructions the...cost per square mile...on the 1-inch scale to be from 6 to 8 rupees. This...is derived from the actual cost of the old Hyderabad Survey [282]. Since that time greater refinements have been introduced, a better and larger class of instruments are used, and more of them, whereby the cost of transport has been increased. ... These causes...will...raise the rate per square mile to 10 or 12 rupees. ... Lieut. Robinson...is now engaged on a map of Jhelum and Rawal Pindi...and the expenditure seems

[1] Thuillier & Smyth (xvii–xviii); 2nd edn. Memo. A. [2] DDn. 591 (232), SG. to Robinson, 18–8–52. [3] *Topo. Instns.*, 1861 (88–106); sd. DGE., 24–7–60, v. *Topo. Handbook*, ch. V (appx. iv); Calcutta, 1913. [4] DDn. 462 (321–2), SG. to Mil. Dept., 13–6–49. [5] DDn. 577 (6), 15–8–51. [6] DDn. 713 (24), SG. to Robinson, 19–1–52.

to confirm the estimate. This rate includes the field work, the original map on the one-inch scale, and the reduction on the ½-inch scale, but it does not include the cost of publication either by lithography or engraving[1] [317–8].

Regarding outturn he considered that, for the Hyderābād Survey, on a scale of one-inch to the mile, every surveyor of average abilities—provided his sections are given over to him with sufficient fixed points...—should be able to execute...4 square miles per diem, or 120 square miles per mensem, or 700 square miles in the surveying season of 6 months.

Capt. Du Vernet informs me that Mr. Chamarett could produce 1,000 square miles in a season with ease, and that he himself would be ashamed to do less on the scale specified. One thousand square miles per season is the maximum to be expected from any surveyor. After he has accomplished that quantity in good style he may return to quarters. On the smaller scale of ½-inch the rate...is 16 square miles per diem, or 2,800 sq. miles per season [282, 289][2].

The encouragement of these large outturns laid a premium on hasty, unreliable work. Robinson called for a much higher standard, and was well satisfied with less than 500 square miles in the season, provided the quality was good, and this he ensured by regular inspection on which the Surveyor General insisted;

The necessity for check is universal, and no trade, profession, or race, is exempt. ... Sound training in the first instance, and vigilant inspection afterwards, are essential to the success of all great undertakings in every country [IV, 258 ; V, 447 ; t-page][3].

COMPUTING & MAPPING

As a general rule a topographical party had rather more work to do during recess than a trigonometrical party, even when, as in Orissa, the field season was cut to four months or less. There were computations of triangulation and occasional azimuths, completion of field sections, two or even three copies of each, and reductions for the Atlas of India. There were preparations for the coming season. Robinson gives this account of his recess work;

When we come into quarters our contingent bills, indents, etc., have all to be made out, and the angle-books require to be examined by two persons other than the observers. ... These duties, together with the finishing up of the planetables of the past season, are, therefore, first taken in hand, and generally occupy a month or three weeks. The finishing of the planetables require much superintendence, and I generally work a good deal at them with my own hands, and endeavour to make the styles...of each surveyor assimilate as much as possible.

As soon as the horizontal angle-books have been examined, the computation of the... triangles is undertaken, being first arranged by myself. ... When the computation of...triangles is completed, the latitudes and longitudes and reverse azimuths...are taken in hand. At first I generally compute a few points with each of my sub-assistants, ... and when satisfied that they can compute well I entrust the mechanical portion of the computations to them. ...

After submitting the narrative report I make arrangements for the computation of the... marks for...planetable surveyors. ... Before I can arrange the secondary triangles I...construct an accurate chart of these points...on a scale of half an inch to a mile. ...

The angle-books...are now fit for copying. ... The vertical angle-books have probably been copied already. The secondary triangles being computed, we next commence the computation of the heights...and in these I also take a leading part. ... I have to watch and arrange...the computations step by step, to look through all bills...and watch carefully the progress of the finishing and shading of the general maps. ... I have to superintend the copying of all our planetables for the use...of the revenue settlement officers [212][4].

The Surveyor General commented on Ouchterlony's maps of the Nilgiris, drawn by MacMahon, an old Madras assistant [179–80, 279];

No. 1 is a very handsome sheet, ... very readable and intelligible. ... On the water system ...it appears to me that many minor arteries have been omitted which, if represented, would have helped to make out the surface of the hills. Along many streams...sheets of watery land are shown, the margins whereof appear...not sufficiently indented to appear natural.

All that part of the map round Ootacamund is nicely drawn, but at the...bottom of this sheet the touches are coarsely drawn and conform neither to the contour lines nor their verticals.

[1] DDn. 547 (363), SG. to AGG. CI., 30–6–55. [2] DDn. 493 (205), S.G. to Brown, Hdbd. Svy., 11–6–49.
[3] DDn. 685 (4), SG. to Robinson, 23–10–56. [4] DDn. 731 (3), Robinson to SG., Aug. 1856.

... I willingly admit the many merits of Mr. MacMahon's drawing, but he should avoid long, horse-tail strokes non-conformable to the ground[1].

The hill drawing of Saxton's maps of Orissa came in for much criticism [170–1 186], and Thuillier disliked "the use of unsuitable flat tints as the ground work of very large portions" [pl. 9], though "a simple colour wash" was accepted as preferable to the use of tree symbols which tended to "obscure the more important features and names[2]". Strange thought the drawing compared unfavourably with Robinson's work [172, 386];

I have a vivid recollection of the beautiful maps of Hazara...under Lieutenant Robinson... and, comparing the Ganjam survey maps, ... the comparison is not in favour of the latter. The execution is clear and neat and...suffices for the ordinary requirements. ... There was, however, an artistic feeling apparent in the maps of Hazara which I do not see in these. But the more important deficiency is in respect to detail. ... It is not the invariable practice here to visit with the planetable every hill. Many hills...and groups of hills are sketched in entirely from below. ... The hills are, one and all, wooded heavily from base to summit so heavily as to derive...a rounded outline not possessed by...the formation. This...must... diminish that...individuality that a rugged and definite outline would yield[3].

To improve the general standard, of drawing, specimens by the best draughtsmen with some copied from European maps were circulated to the topographical parties. James' hand-book formed part of the campaign. Waugh noted that Robinson had

a very good knowledge of military drawing and a natural talent for sketching ground. I selected for the senior assistant of this party the best draftsman of the Trigonometrical Survey, who has devoted himself with so much...ability to this fascinating...duty that he has made a very close approximation to perfection. To John James...I am indebted for the originals of these specimens. ... The great merit of the originals is—truth to nature. ... I wish this to be impressed on Lieutenant Depree, on whose talents and Addiscombe education I rely to produce a thorough improvement in the Ganjam survey [386][4].

He writes privately to Thuillier;

These topographical surveys have given me no end of anxiety. They want teaching in fundamental rudiments of drawing. I have at last got such a series of exquisite topographical drawings ready as will do your heart good to look at. ... Tennant and Scott say they are sweet bits, but how to get them copied for all the parties, that is the rub. Two are being copied for the Kashmir party, and will go to you in a day or two. The copies, tho' not quite equal to the originals, are very well done and a great credit to your pupil Ghoolam Kadir [343]. ... I used once on a time to be a very good military draftsman, I flatter myself, but this horrid red tape system of office prevents a man doing anything but quill driving, instead of real work. The Indian system of Government is paper, pen, and ink[5].

James was an exceptional draughtsman and was Robinson's head assistant till appointed head draughtsman at the Calcutta Drawing Office in 1857 [353]. His *Topographical Surveyor's Handbook* was published in Calcutta in 1860, and contained easy lessons for beginners in hill-drawing and shading. Selections...taken from the best maps. Many original sketches of hills and ravines—Charts of principal and secondary triangulation —Specimen of a route survey and ray-traces—Sheet of topographical items or symbols—Designs for titles, headings, and footnotes—Borders, north-points, and scales. ...

With many useful notes and hints to the topographical surveyor and draftsman.

The sale price was ten or twelve rupees according to the binding[6].

Even though grumbling about red tape, Waugh was just as insistent as Everest on strict rule and order for all details of Departmental work, as in this order on headings and footnotes;

Elaborate ornamentation in the titular descriptions of maps is not consistent with the good taste which distinguishes scientific workmen. The intrinsic value of a sheet of survey is generally in the inverse ratio of the pretension of the title. ... Precision in the language...and a careful pruning of all redundant words are sure indications whereby to know a good map. ...

I may cite the word "Map" or "Survey", ... the use of which...appears to be as absurd as it would be to write under a picture "this is a man", "this is a horse". The thing should

[1] DDn., 580 (12), SG. to Ouchterlony, 31-8-52. [2] *GR. Topo., 1860-2* (35–6); DDn. 665 (293), SG. to DSG. 10-12-56. [3] DDn. 697 (121), to SG., 5-7-56. [4] DDn. 665 (244), SG. to DSG., 7-10-56; ib. 578 (225), DSG. to Depree, 10-11-56. [5] SGO. fd. corr. Oct. 1856. [6] DDn. 666 (164), 701 (83); SG. to DSG., 24-7-60.

speak for itself. ... Your survey...should...be simply entitled "The Districts of Jhelum and Rawul Pindee on a scale of 1/63,360".

Every individual concerned in the field survey, office computation, projection, of a map, and drawing thereof, should have his name and share in the work recorded thereon. ... It does not appear convenient to engross all this information with large ornamental printing forming the title [IV, pl. 15]. It seems to be in better taste to put the names in a running footnote along the base of the map. ...

A Title...should be concise. ... Some sheets will be full, without space for a title, and in that case the map should be described in a...line of small print along the upper margin[1].

Great store was set on the regular submission of monthly progress reports [126], and the Surveyor General writes to Du Vernet ;

Even if acting perfectly independently it would be necessary for an officer at the head of any well-regulated establishment to review periodically his own proceedings, as well as those of his subordinates. ... I enclose a form...well calculated to furnish a clear view of the progress of the work. Each subordinate on detached duty should report to you on the 1st of each month, and their reports should be annexed to your own for my information. ... The matter may thus be so condensed as to give a clear view of the progress...completed in 10 minutes.

In this way a wholesome moral effect must be produced throughout your party, as everyone will be thereby led to reflect on his past proceedings, and to endeavour to attain professional credit by his future exertions. Unless a man's work is duly reported, he can get no credit for it and, feeling that his services are unacknowledged, it is only natural that he should become apathetic and indifferent[2].

BENGAL REVENUE SURVEYS[3]

From time immemorial large revenues had been raised by taxes on the produce of the land. Assessment of these revenues and the methods of collection had varied from province to province, and from age to age. Assessment was often quite arbitrary, imposed on subordinate states, townships, chieftains or landowners, according to their reputed capacity to pay. In other cases a serious attempt was made to judge the capacity to pay by measurement or estimate of the area of the land and the value of its produce. Collection of land revenue was often effected through middlemen or "farmers", who were left to squeeze the cultivators as they liked [I : 137–8]. In some cases revenues had to be collected by armed force. It was a time-honoured custom to reward faithful service by the grant of *jāgirs* or rent-free land.

Ownership of land was a highly-prized privilege, and record of possession was jealously guarded, and in most areas methodically registered by local officials such as *patwāris* and *kānūngos*. Where ownership rested with the individual cultivator, tenures or holdings tended to break up into minute fragments through the laws of inheritance. It was to facilitate the collection of revenue that the British introduced the permanent settlement in Bengal at the end of the 18th century, by which Government collected a fixed annual sum from individual or joint owners, whose estates were often quite undefined, and frequently broken up by sale.

Early in the nineteenth century it was realized that it was impossible to arrive at a just settlement of revenues, fair to both Government and owners, without an accurate survey of lands and boundaries. The traditional survey methods by rope or rod, though serving to give the area of a few fields, were by no means sufficiently accurate to give the area of an estate or village, though by close control Thomas Munro had carried out such a survey between 1802 and 1807 [II, 180–2]. On the Bombay surveys of 1810 to 1827, British surveyors had with theodolite and chain, triangulation and traverse, produced village maps on scale 6 inches to a mile which gave "the name and...residence of every landholder, with the number of his fields and their situation and measurement" [II, 189 ; III, pl. 16].

[1] DDn. 592 (106), Circular, 7-9-54. [2] DDn. 526 (248), 28-3-50 ; cf. DO., 13-5-56. [3] Accounts of early surveys, I : 133–47 ; II, 177–89 ; III, 134–65 ; IV, 177–82, 205–9, 229–34, 235–9 : cf. *Blue Book* ; *Rev. Srys. NWP.* 1855 ; Hirst, 1912 ; DDn. 554 (12).

On the surveys in the Upper Provinces of Bengal between 1822 and 1833 so much stress was laid on precision and topographical detail that progress was far too slow, and from 1833 they were reorganized. Professional surveyors were given control of the field, or *khasrah*, surveys, with establishments by which each party was, from 1837, able to turn out about 3,000 square miles in a season. In the lower provinces the country was more difficult, and property more closely subdivided, so that such high outturns were impossible [IV, 179].

In Bombay between 1826 and 1831, another attempt was made under civilian control to extend survey over the Deccan by the ancient methods of the country, but the results were unsatisfactory, and from 1837 military surveyors were again called in. A new system was introduced by which fields were surveyed with simple instruments, and village maps produced, but without any survey of topographical detail, and without either trigonometrical or traverse control [IV, 235–6].

After 1847 many changes and improvements were introduced in Lower Bengal under the professional administration of Henry Thuillier. One of the most important problems was that of cooperation with the Civil Superintendent of Survey, who was responsible for the settlement and demarcation of boundaries in advance. The Surveyor often had great difficulty in recognizing the limits he had to survey, which gave rise to serious discrepancies between the professional survey of boundaries and areas and the detailed field measurements [246–7]. From 1850 responsibility for the *khasrah* survey was transferred to the Civil Superintendent, who was at the same time given adequate staff for providing the Surveyor with clearly defined boundaries to survey. The Surveyor was then able to concentrate on the survey of his boundaries and topographical details, and cooperation was more satisfactory.

Work proceeded smoothly on this same general system in the new surveys that were started in Upper India and the Punjab from 1846, whilst in Madras work was started in 1857 on an entirely new system which brought survey and settlement into the closest alliance.

General procedure on the Bengal surveys may be illustrated by extracts from instructions issued in 1849 by the Government of the North-Western Provinces ;

22. The survey is to follow demarcation of boundaries with as little delay as possible.
23. The survey is of each field, for revenue purposes.
24. A field is a parcel of land in occupation of one cultivator [with special authority several fields could be blocked together to form areas not less than 3, or sometimes 10 acres].
25. Survey to consist of two parts, scientific and *khasrah*.
26. Scientific survey on 4-inch scale lays down village boundaries and geographical features.
27. Theodolite and chain are used on a system of circuits. Geographical features fixed by intersecting lines and bearings[1].
28. The Interior Survey lays down cultivated area by planetable, or by compass and perambulator.
29. *Khasrah* survey consists of a *shujrah*, or native map, and *khasrah*, or list of fields.
30. The *shujrah* and *khasrah* are the important documents to the Settlement Officer, and the chief attention of the surveyor should be directed to them.
31. The scientific survey is of great value as a check...and for giving topographical and statistical information, but these objects are secondary. ...
32. Boundaries must be well marked, and every assistance given to surveyor in picking them up[2].

The Settlement Officer was more interested in the component field areas shewn in the *khasrah* than in the total which was verified by the professional survey ;

It has always been the custom in the North-West Provinces for surveyors merely to find the total area of the village circuit, leaving the areas of cultivation, waste, fallow, and other qualities of land, to be recorded by the khusrah, which is a separate process conducted by distinct parties, and in no way obtained by professional or scientific means. ...

An agreement between the two operations is first necessary, and if the aumeen's measurement coincides with the...professional survey within 5% it is confirmed and passed [300]. The khusrah area, however, ... does not affect the professional one which is still retained and recorded, every village map being lodged in this office, with its area, calculation, and proof by traverse, duly noted on the back [IV, pl. 12]. ...

The necessity for a khusrah measurement in each district rests with the local civil authorities. ... If an assessment is to be made, then, of course, the khusrah is absolutely essential. In the perpetually settled districts of Bengal, where the operations are proceeding only...to define the estates paying jumma to Government, the khusrah is only partial, that is, such

[1] cf. *Agra Sel.* I, 1846–9 ; Svy. ; Wroughton. [2] *NWP. Directions* (32–40) ; Thomason, 25–8–49.

villages merely are included...as contain such minute interspersed pieces of land belonging to other villages as cannot be extracted by the professional work. ...

In neither case are the separate areas of cultivation, waste, and fallow, required, it being out of the power of Government to alter the existing settlement[1].

Thuillier stresses the responsibilities of the professional surveyor ;[2]

It is incumbent...on officers in charge of surveys...to satisfy themselves...that the main circuits are actually worked out and proved prior to the village circuits being calculated. ... Disclosures on the 24-Pargannahs survey shew a most culpable negligence on this point [248]. ... In connecting districts together...greater attention is required, and especially where a river like the Ganges intervenes. The triple boundaries of exterior pergunnahs being permanently marked...by the party first advancing there would be no difficulty in the other surveyor subsequently making a perfect connection [262]. ... Great difficulty has been experienced in reconciling discrepancies in some of the districts bordering on the Ganges, owing to both surveyors having omitted the opposite bank of the river. ... As a general rule...the river should be included in the operations of the party which last approached[3] [245, 252, 296].

[to Davey on the Dacca survey]—You have omitted to shew both banks of such important rivers as the Booree Gunga, Dullasery, Sukhya, and the Jamuna, which is of the highest importance. ... The five maps will be returned to you...in order to have this important addition made to them, and until this is done they cannot be sent to the press to be lithographed[4].

Where a boundary was in dispute it was the surveyor's duty to survey both lines under dispute, especially when both are shewn in the thakbust map.

The decision of the Deputy Collector deputed to adjust disputes is not final. His orders are appealable to the Superintendent and Commissioner, and, under the law, the period of appeal to the Commissioner is three months. ... No circumstance...can justify a surveyor in adopting his own boundaries. He might, if he saw fit, return the thakbust for correction, but he was not at liberty to assume his own boundaries [247][5].

In his General Report for season 1854–5[6], Thuillier gives a summary of the surveys carried out under his control,

or since the season 1846/7, about which time the renewal of operations was made after the suspension...in 1842. In the season of 1846/47 the cis- and trans-Sutlej States operations were opened out. The Punjab proper followed them in succession, and in the succeeding season a revival of the Revenue Survey was undertaken in Ajmer & Mairwharra, subsequently in Rohilcund, and latterly in the Saugor & Nerbudda Territories of the N.W.P. ...

In the nine last regular seasons we have...as the results of the combined efforts of the 13 different parties...a grand area of 1,12,271 square miles effected at a cost of rupees 26,18,070, or at an average rate per square mile of Rs. 23–5–1. Bengal, 5 surveys, 46,810 square miles—N.W.P., 4 surveys, 15,189 sq. miles.....Punjab, 4 surveys, 50,272 sq. miles [IV, 209, 234].

The extraordinary cheapness of some of the old N.W.P. surveys, produced by the lamentable haste with which the ground was got over, ... from the effects of which the public service is now suffering, of course influenced the average [IV, 218]. ... For the money now expended we have...full and faithful maps...available for all purposes. ...

The boundary of every village has been...defined and mapped on the scale of 20 chains to the inch, with the exception of the...independent States in the cis-Sutlej Territory, ... and the sterile tract of waste forming the southern portions of the doabs in the Punjab proper, called the barh, where a...delineation on the one-inch scale only was permitted. ...

In Behar and Bengal, where the perpetual settlement exists, the object...is merely to obtain a correct record of the area and positions of every Estate on the rent roll, ... No new settlement is in progress or contemplated. ... The minuteness of the division of property in the Lower Provinces, however, is extreme ; therefore the village survey is imperative. ...

The village boundaries and geographical features only are thus laid down by the professional establishments, ... the smaller Estates...by the civil department. ... Prior to 1850 the duty of the professional surveyor embraced all the measurements of internal estates...by...the khusrah. ... The field by field detail measurement was in 1850 abolished...in favour of a system...by which the exterior sides only of all the small interspersed estates...are now laid down. ... The whole of the internal Estates...are protracted...on a scale of...16 inches to the mile [295][7].

Thuillier did not like this change because of the divided responsibility it entailed.

[1] DDn. 472 (263–75), DSG. to SG., 24–11–47. [2] Thuillier & Smyth (311). [3] DDn. 472 (409–15), DSG.'s CL., 1–3–48. [4] DLR. 37/50 (194), 28–2–59. [5] DDn. 582 (146), Rev. Bd. to Rev. Dept., 16–7–55. [6] c. SG.'s *Triennial Report* 1854–5 , SG., 16–7–55 ; DSG.'s Report, 2–5–56. [7] DDn. 624 (3–6), DSG. to SG., 2–5–56 ; cf. *Blue Book, Rev. Srv. NWP.* ; DDn. 554 (12), 8–8–56.

A valuable review of the revenue surveys was made by Colonel Dickens in 1864. After telling of the hasty work in the North-Western Provinces he notes that

> the survey of Hooghly and Midnapore are defective in demarcation of boundaries...from imperfect professional work, and some of the older revenue surveys are, like those of the N.W.P. defective in topographical detail. In all the latest revenue surveys in Bengal the professional work is excellent. ...
>
> The professional 4-inch village maps of all recent surveys are good and are constantly being improved. The village khasrah plans on the large scale of 16 inches to a mile produced under the civil officers are wanting in the rigorous accuracy of the professional survey [294]. ...
>
> The weak point of this Bengal system...of 1850 was that all interior measurements by the amins were left unchecked by professional agency. ... This fault was avoided in the Punjab where the professional...surveyor was required to apply every possible test to the khasrah under their supervision [303][1].

CONNECTION WITH G.T.S.

Though some of the western surveys had been connected to stations of the Great Arc and the Budhon Series[2], the earlier revenue surveys had preceded the Great Trigonometrical Survey, and their maps had no geographical control. Those of the later surveys of the North-Western Provinces were practically devoid of topographical detail, but at the instance of the Board of Revenue they were lithographed at Allahābād just as they stood, and here, writes Dickens "the Great Trigonometrical Survey...stands as a skeleton without a body, no topography having been based upon it". As data from the meridional series became available in Bihār and the Lower Provinces, special editions of the ¼-inch district maps were compiled in the office of the Deputy Surveyor General after connection by such points as could be identified, and these were then sent to London for incorporation into the Indian Atlas. Such connection could not, however, be really satisfatory so long as triangulation followed the detail survey [IV, 288–90 ; V, 282].

Waugh took up this question of "intimate union between the Great Trigonometrical operations and the Revenue Survey" as soon as Wroughton took over as Deputy Surveyor General in 1844 [312–3]. They agreed that where the revenue survey preceded triangulation the surveyor should establish recognizable marks ;

> We concur in considering the triple junction boundary points (tokas) of pergunnahs as the proper stations of union because these points, being common to three boundaries, will enable the junction to be effected with the smallest number of stations, and therefore at the least possible expense and most accuracy. These points should be marked...by small masonry platforms...covered with a mound of earth...to protect them...from mischievous violation. ... The expense should be defrayed by the villages. ... A description of their localities...should be recorded...with an illustrating plan [262, 296].

The revenue surveyors were to record the co-ordinates of these trijunctions and other prominent, point just as Wroughton had done on his own district surveys [IV, 228, 233, 289–90]. This would facilitate recompilation from original materials,

> instead of being dependent...on the unsatisfactory processes of copying, enlarging, or reducing former maps. ... All maps are liable to deterioration in the course of time from the expansion and contraction of the paper, and the crumpling, rolling, and folding thereof, and as all such discrepancies are perpetuated, and indeed augmented, in the process of copying, ... the value of such maps must be continually depreciating unless we have the means of resorting to numerical data for their...reconstruction[3].

Whilst the revenue surveyors were ordered to erect these pillars and to supply copies of their maps to the triangulators [253][4], officers of the Great Trigonometrical Survey were instructed to run frequent secondary and minor branches, for "Stations of the principal triangles very rarely coincide with known points of any prior survey and it is therefore to the secondary points that we must chiefly look for the means of verifying and connecting the labours of former surveyors" [119][5].

[1] Dickens (16–24). [2] eg. Muttra [IV, 233]. [3] DDn. 491 (33–5), SG. to DSG., 15–4–44. [4] DDn. 623, 25–1–49 ; DLR. 36/27 (121), 27–2–49. [5] DDn. 471 (5–12), oo. DSG., 26–4–44 ; 515 (277), SG., 12–9–44.

Responsibility for proper connection was laid upon the party last to visit the ground, [294] but the lapse of two or three seasons often made it difficult to identify a tri-junction, and triangulation stations were sometimes swallowed up by a swollen river. In 1845 Logan sent in the coordinates of four secondary stations

which will afford the means of connecting the revenue survey...with the triangulation. I regret that owing to the difficulty of identifying the...stations at the triple junctions of pergunnahs, it was found impracticable to form a more perfect connection. ... Instead of the usual slight marks which are generally made, ... a more permanent one should be left at a few of the stations, or what would probably answer better, a list of the temples or other permanent and easily recognized objects...should be furnished to me.

Two of the sub-assistants...were employed for a month last year, and even with the assistance of a tindail sent by Captain Sherwill...only four of them could be sufficiently identified[1].

Wroughton had difficulty with

the surveys conducted under the North-Western Board. No attempt was made to effect a satisfactory junction with...the Trigonometrical Survey. In some cases a partial union was effected, but for the most part it has been neglected. ... I am...recompiling the...district maps on the best data obtainable, that they may be eventually lithographed [312–3].

He had no difficulty however with his own surveys of Etāwah and Sohāgpur [IV, 222, 228] which had been based on the Trigonometrical Survey points,

and have otherwise been compiled topographically with every care and attention. ... With a view of their being eventually united on the trigonometrical survey, ... the latitudes and longitudes of several points of the latter operation have been identified with similar points fixed by the Revenue Survey[2].

Pemberton was directed to employ a special detachment for connecting up the towers of the Calcutta Meridional series which had been built after the close of the Purnea survey;

A very simple survey of the geographical features round each tower separately is necessary Every village site in the neighbourhood of each tower must be laid down, and each site connected with the tower by angular and linear measurements, and...with each other. A list of the name of places wanted round each tower is annexed. ... Each tower will therefore form a starting point for...a sort of route survey round, through, or up to each village site[3].

Satisfactory connection was particularly difficult when

the G.T.S. operations follow the revenue survey. ... All or nearly all, the nearest villages on opposite sides of the station should be laid down by some means, otherwise it is very probable that the positions of the tower stations...will not agree with the sites of the villages on the...maps, more especially when the villages are close upon one another. ...

The districts of Pooree, Cuttack, and Balasore, surveyed from 1837 to 42, remain yet unconnected with the trigonometrical survey...in consequence of the only secondary points... laid down by the Coast Series being hill marks, trees, and rocks, objects which are not noted on revenue maps. For the past ten years I have used every possible means to induce the officers conducting the Coast Series to return me the one-inch maps of the Revenue Survey... with the positions of their stations shewn thereon, but...without success. It is easier for the officers conducting...triangles across a district, map in hand, to shew the positions of his own towers or stations than it is for this office to insert them from mere linear values [23][4].

The programme of the Punjab triangulation parties was frequently adjusted to help the revenue surveyors [37, 50, 52, 210], and Logan was specially directed

to cause a minor series to be run as far as Lahore and thence across the doab, ... whereby the positions of numerous geographical points...will be established in the upper part of the Baree doab. ... For the Rechna doab the triangulation down the Ravi will also furnish points at moderate intervals apart along the eastern boundary, while the party working along the mountains towards Peshawar will be able to lay down numerous other stations...including the towns of Sialkote and Wazirabad. By next season I hope to send a triangulation party down the Chenab...and to connect at Shadhara and Lahore [118][5].

[These operations] will be of no value if the marks cannot be found by the Revenue Surveyors. Permanence can only be secured by masonry marks. ... If they are built after the observations the mason employed must be taught to conform explicitly to the station mark ... In all cases marks should be made on the ground to attract the eye. The revenue survey use

[1] DDn. 560 (152), Logan to SG., 31-7-45. [2] BRC., 11-3-46 (4), DSG. to Rev. Bd. 9-2-46; cf. Mirzāpur map (IV, pl. 14]. [3] DLR. 37/51 (99), from DSG. 22-2-51. [4] DDn. 667 (39), DSG. to SG., 10-5-59. [5] DDn. 478 (9), SG. to DSG., 12-9-50.

trenches forming a cross which are said to be visible for two years, and they cover the station piers with charcoal and a mound [260][1].

For minor triangulation, writes the Surveyor General,

a marking party follows along each bank erecting small masonry blocks at the station of observation. These blocks are cylinders 3 feet in diameter and 2 feet thick, whereof 1 foot is foundation. ... If you can have them constructed for Rs. 2 each it would be not desirable to leave any station unmarked, except those...liable to be covered by the river. ... Such stations should...be not less than 3 in number, forming a triangle, so that if one be lost there may remain two others to define a distance and azimuth[2].

Tennant found the ½-inch *pargana* maps most useful on the Gurhagarh Series ;

They are deficient in topographical details, but from their geometrical accuracy gave great facilities in enquiring after sites of stations, ... and the practice of inserting villages...with some regard to their size was most useful in guiding me in procuring supplies. My early stations were plotted on them by interpolation from the neighbouring recognizable points. Towards the end I adopted the plan of connecting a trijunction mark...near the station. ... The additional labour is trifling, and the certainty with which the stations can be placed, ... and the revenue survey data incorporated without...secondary stations...will recommend this practice[3].

TRAVERSE CONTROL

The system of traverse surveying in circuits by theodolite and chain had been followed by Barnard in his survey of the Madras *jāgir* between 1768–72 [I : 142]. After the start of the surveys of the Upper Provinces under Hodgson in 1822 regular closing and proving was laid down by order [III, 148][4] and closely followed later in Bengal surveys [III, 159–63 ; IV, 208–9 ; pl. 12].

Up to his appointment as Surveyor General at the end of 1843, Waugh had no contact with revenue surveys or their problems, and within a month he was called to give professional instructions for the revenue survey of Kaithal [268–9]. He replied with a long note on the first principles of traverse survey based on triangulation, drawn in part from Herbert's pamphlet of 1830 and from instructions issued by Bedford in 1834 [IV, 205 n.6, 213, 232]. Brown thought many of his suggestions impracticable and considered that the N.W.P. surveys were sufficiently checked by the frequency with which adjacent circuits were connected up[5].

The following year Wroughton sent to Ouchterlony for his survey in the Nilgiri Hills a very clear and detailed description of a traverse survey over hilly ground. In addition to theodolite and chain he recommended that the surveyor should work with a cross-staff and offset rods for picking up detail to right and left similar to those used by the Bombay surveyors [IV, 237–8]. In describing the break-down of the traverse into rectangular co-ordinates he quotes Charles Hutton [I : 248], who observed "that this mode of surveying large tracts of land...was made use of by Mr. Norwood so far back as 1635"[6]. He further notes that in Bengal the surveyors worked from "either Boileau's or Egerton's Traverse Tables [IV, 232], and that other technical details may be found

in any work that treats upon traverse sailing, or close topographical mensuration. It is fully explained in Adams' Geometrical Essays, but more particular in an American work called "Theory and Practice of Surveying" by Robert Gibson [IV, xvii, 232 n.5][7].

Secondary triangles based, if possible, on primary triangulation of the Great Trigonometrical Survey, are first established, and a circuit survey by traverse is effected of every sub-division or pergunnah. ... The true position of the village is determined by...the angles subtended from it to three points of the surrounding secondary triangles. ... "The theorem of the Three Points"...is explained in Adams' Geometrical Problems under the head of 'Curious and useful Trigonometrical Essays [289]'[8].

[1] DDn. 493 (346), SG. to Logan, 27–9–50. [2] DDn. 591 (249), to Strange, 24–9–52. [3] DDn. 695 (4), Tennant to SG., 7–6–59. [4] introduced by Thos. Oliver on the Delhi Svy. [5] DDn. 451 (15), NWP. to SG., 6–1–44 ; 452 (79–94), SG.'s reply ; 29–1–44 ; DDn. 454 (28–40), note by Brown, 11–2–44. [6] Hutton's *Mathematical Tables* (174), 3rd edn. [7] *Treatise of Practical Surveying.* London 1767 ; new edn. by Trotter, Dublin, 1839. [8] 4th edn. (169), "Townley's Theorem" ; DDn. 471 (1–14), DSG. to Ouchterlony, 5–3–45 ; *NWP. Sel.* I, 1847 (iii).

To keep close control of the work of his Bengal parties Thuillier required regular reports on circuit closing errors. In 1855 he introduced the system of main circuits which greatly simplified computations and mapping [305–6].

Each main circuit may contain from 50 to 100 or 200 square miles, and many traverse village circuits...congregated together as may be convenient, ... so that the shape of the circuit may be as compact and symmetrical as possible without any reference to the sinuosities of either pergunnahs or estates whereby the angular observations and linear measurements will be reduced and the traverse proof rendered more certain.

Only after each main circuit had been closed and proved were the sinuosities and fragments of boundaries to be surveyed by interior traverse circuits [251][1].

As each survey laid out its own system of rectangular coordinates springing from its own origin and independent azimuth, discrepancies naturally appeared along the junctions. This was first brought to official notice in the Punjab by Shortrede, and Thuillier consulted the Surveyor General;

Major Shortrede follows the practice of correcting his angular work for the convergency of meridians. ... By observing for azimuth at intervals of 10 to 13 miles, and allowing for convergency according to the distance from origin, he gets a check on all the intermediate angles, thus providing against accumulation of error. ... I have hitherto been apprehensive as to adopting a uniform system of allowing for convergency because it is not all surveyors who readily understand the subject which is one of some difficulty. ... I would solicit your advice[2].

The subject was again brought forward by Anderson from the Sind-Sāgar doāb, and it was ruled by the Surveyor General that

each revenue survey should be of moderate extent, especially in longitude. Each should have its own independent first meridian...near the centre of each survey. ... Each survey should be projected on the principle of parallel meridians, but the true observed meridian should also be drawn on the map at every point where meridian observations were taken. This will facilitate comparison of boundaries and geographical compilation[3].

INSTRUMENTS [IV, 148–50]

The Surveyor General was impressed by the enormous demand made by revenue surveyors for supply and repair of instruments;

The work which a theodolite goes through in revenue survey is very severe; ... they are no doubt, frequently used without due care [IV, 148–9]. Every instrument requires periodical cleaning and adjustment. ... The limb should not be dusted except with a fine camel's hair brush. Once a year in the rains the silver graduated limbs should be gently washed with soap and water, and then cleaned with a piece of old silk, some fine olive oil, and a little lamp-black. ... The best oil for the axis is goose or duck oil [IV, 54 ; V, 163]. ...

The classes should be 12-inch, ... 7-inch, ... and 5-inch. ... I acknowledge a prejudice against any instrument smaller than 5-inch, ... mere playthings fit only for surveying a garden or compound. ... The officer-in-charge of a district survey ought to have a 12-inch theodolite for the main circuit and for determining the true meridian. ... If the telescope ranges to 40° of altitude it will command a view of circumpolar stars at their elongation in any part of India. ... The 7 and 5-inch...should also be made by Simms, on Colonel Everest's pattern [IV, 144]. ... I ...advise you not to admit any of Robinson's pattern. ... I know from experience how very inferior they are[4].

Thuillier, on the other hand, preferred sextants for observing the azimuth, and thought a 12-inch theodolite far too cumbersome; "Portability is absolutely essential in operations which have to drag their weary length...in the densest jungle, and where each line is obliged to be cut through[5]" [131].

In support of his indent of 1853 he wrote that the demand for

theodolites, ...must continue heavy as long as so many regular survey parties are employed in the Punjab, in the North-Western Provinces, in Bengal, in Arracan, in Pegu, and in the Straits [349], to say nothing of the wants of other branches of the public service. ... Since...1850 only 13 theodolites...have been received from England, ... and 6 more are expected, ... whilst indents have been passed for twice that number [165–6].

[1] DDn. 623, co., 26–1–55. [2] DDn. 624 (67), 5–4–56. Thuillier & Smyth, 5th edn. (appx. cxix).
[3] DDn. 32, (164–73), note by Hennessey, 30–1–60 ; by SG., 1–2–60 ; cf. note by STS., 6–9–70 ; DDn. 7 (235–7).
[4] DDn. 473 (89–96), SG. to DSG., 28–12–48. [5] DDn. 474 (16–21), Jan. 1849.

Stock for 10 field parties numbered 168, made up of seventy 4 and 4½-inch—forty-nine 5 and 5½-inch—thirty-nine 6 and 7-inch—ten from 8 to 12-inch. Of these 113 were made by Troughton & Simms, 10 by Barrow, 1 by Robinson, 6 by Gilbert, and 2 by Cary[1]. By 1856 another consignment of 57 five to seven-inch theodolites had arrived but,

since there are no less than 14 large parties in the revenue branch alone, ... each party employing from 20 to 30 theodolites, the number now received will not go very far, since a large proportion...now in use urgently require to be exchanged. ... Heavy requisitions are...coming in from the Department of Public Works. ... The supply...of patched-up instruments of old construction, and by obsolete makers, finds, as might be expected, no favour in the present day[2] [164].

Chains had constantly to be replaced and, writes Sherwill,

The fifty chains with the party were purchased in 1839 and have been constantly in use, having been used to survey Benares, Hamirpore, Bandah, Behar, Shahabad, and Monghyr. Twenty of the 50 have been broken up to repair the continual breakages and to complete and lengthen the remaining 30. A great increase of khusreh work in Monghyr, and the necessity of longer chains from the great length of the local luggee is the cause of the indent [IV, 208 ; V, 302][3].

Tickell repeated the demand two years later, explaining that the local unit was a chain of 90 feet and that "the ameens will be much perplexed by the introduction of a shorter one". Pemberton found that he could get chains made up locally at Rs. 5 each "but perhaps the materials may not be as good as supplied at the Mathematical Instrument Maker's[4]". It was only recently that chains had replaced "common ropes for *khasrah* measurements, a change which cannot fail to produce a better comparison between the...two separate operations".

Amongst other articles supplied from the workshops or by local purchase were

Brass plates perforated so that the projection of a rectangular grid could be pricked through. Rs. 3 or 4—Standard steel bars, one pair for each camp running main circuits—"Bengalee Compasses" ; Rs. 14 each[5].

DEMARCATION OF BOUNDARIES

In Bengal it was provided by law that boundaries of estates and villages should be demarcated at the expense of owners and villagers ;

The demarcation...is of villages, not of fields. A village consisting of several fields and constituting one mehal or estate has its boundaries decided and marked off, and is separately assessed. ... The Revenue Officer marks off at the expense of the parties the boundary he has fixed...before the survey, in order to admit of the uninterrupted progress of the survey. ... The village proprietors...are well aware...of the importance of having them well marked[6].

It frequently occurred that through lack of sufficient planning in advance the boundaries were neither settled nor demarcated in time for the survey to commence, but even when endowed with magisterial powers the Surveyor had no authority to decide himself on the boundary to be surveyed [IV, 179 ; V, 247, 294] ;

Wherever a Surveyor has attempted to lay down boundaries for himself, loss and embarrassment have been the result. How little to be trusted Captain Mathison's boundaries are in Midnapore has been shewn by the partial revision...in 1845 [246]. ... In Hooghly Mr. Wilson's inability to follow the maps of the revenue parties determined him on taking a similar course, and led to his own dismissal and to the condemnation of his survey [247–8, 304]. If the civil duty of laying down their own boundaries is to be made over to the Surveyors and their assistants, it should be after their passing the examination in revenue law...and...by serving for a year or two in a Collector's office [170, 398][7].

There were many complaints of the slovenly way in which the *thakbast*, or *hadbast*, description and sketch of the boundary was prepared, and of its disagreement with marks on the ground, involving infinite delays. Smyth reports from the 24-Parganas that he was "treading as it were on the heels of the Deputy Collectors and in consequence make no progress myself"[8] [248].

[1] DDn. 563 (112), DSG. to Mil. Bd., 30–8–53. [2] DDn. 662 (43), DSG. to IG. Ord., 1–2–56. [3] *laggi* = pole. [4] DDn. 482 (44), 4–2–46 ; DLR. 37/63 (63), 6–2–49 ; 36/17 (155), 14–9–48. [5] BRC., 30–7–45 (39); DDn. 474 (16–21), DSG. to SG., Jan. 1849 ; B to CD., Rev. 25–3–50 (33). [6] BRC., 6–5–44 (9), from NWP. Govt. [7] *Rev. Sty. LP.*, 1852–3 (68). [8] *hadd* = boundary ; *thak* = mark ; DLR. 39/68 (272), 12–3–49.

The rearrangement of duties in 1850 gave the civil staff definite instructions for the preparation of *thakbast* papers and sketches based on careful measurements[1], so that the surveyor might follow the measurements shewn in the *misl* [IV, 205 ; V, 248].

The old plan was...to mark out the boundaries...upon the ground and to make an eye sketch of them. As no care was taken to make this demarcation...immediately precede the survey, the Surveyor when he came to the ground a year or more afterwards found marks removed, ... and the eye-sketch and written description...so ill done as to leave him at a loss. ... Sometimes...he took wrong boundaries, and...the fact might long remain unknown[2].

Though Thuillier did not like all the changes introduced in 1850 [294], he agreed that "the thakbust operations...have been placed on a sound and efficient footing, and that nothing but direct neglect...can endanger the proper working of the system". The Surveyor was now to be "independent of field marks, or—when they are obliterated—...by the help of the thakbust missil and map will be able to follow the same identical boundary, and lay it down professionally on his map"[3].

FIELD SURVEY OR *khasrah*

Accounts of the detailed *khasrah*, or field measurement made by Indian measurers or *amins*, have already been given [IV, 205]. This *khasrah* was the basis of the revenue settlement, and with the rough sketch, or *shujrah*, was sufficient for the assessment of revenues, though not sufficiently precise for the village area and map. Whilst, however, it fell under the management of the professional surveyor it was natural that he should strive to improve the accuracy so that the field measurements should conform with his professional survey, and at the same time provide topographical detail for mapping purposes.

In Bengal and Bihār where large areas fell under the permanent settlement it was only necessary to carry this field survey in areas where the estates were small and much broken up, with intricate boundaries [IV, 180 ; V, 244–5].

First-class work could hardly be expected from *amins* engaged on a temporary basis on wages but slightly higher than those paid to unskilled labourers;

The greater portion of the villages [writes Smyth]...will have to be remeasured. Those that do stand the test at present are only just within the percentage allowed. There appears to have been great carelessness also on the part of the aumeens in keeping the fieldbooks. None of them are perfect, the zemindar's names, talooks, etc., being omitted, and but few bear the signatures of the several malikans [proprietors]. These individuals appear to have an extreme objection to attaching their signatures to any office document, and I have no doubt their reason for not signing fieldbooks is their knowledge of the careless and indifferent manner in which the khusrah measurements were carried out[4].

Smyth's *amins* worked on a contract rate which in 1849 he raised to Rs. 4 per 100 acres [IV, 199 ; V, 302]. Their work was only accepted if their areas measured up to within 5% of the professional survey [293].

Thuillier considered the transfer of the *khasrah* to the Civil Superintendents in 1850 an unwelcome and retrograde step;

Rough field measurement...was executed by expert native ameens who had acquired wonderful accuracy of eye, ... the measurement of the fields being conducted according to the comprehension of the landowners with a simple rope or rod only. ... With...checks...the Surveyor was enabled to produce results which tallied within 5 per cent of the professional area[5]. ...

In Lower Bengal, where the intricacy and number of estates is great, ... and where interlaced and detached parcels of the same Estate lie in all directions in the utmost confusion... the abolition of the field measurement was, according to my humble judgement, a most fatal error, and my most strenuous objections were recorded at the time. ...

For...ascertaining the true areas of these minor estates the external demarcation system has proved a lamentable failure, because the error involved by such a multiplicity of measurements and observations in the interior of a single village with rude instruments and rude native hands, untaught by professional or competent persons, is out of all proportion.

[1] Rev. Bd. to Govt., 8-4-50; & Govt. sanction, 1-5-50. [2] DDn. 562 (144). BRC., 16-8-51 (39), to Rev. Bd. [3] Report 1849-50, Rev. Bd. to Govt., 10-10-50; DLR. 36/33 (211), DSG. to Wyatt, 15-4-50. [4] DLR.37/64 (238), to DSG., 23-12-47. [5] DDn. 624 (4-5), 2-5-56.

Parcels of different Estates are found in hundreds and even in thousands scattered all over a village. ... It has been the practice of the civil department to deduct the incorrect areas from the true and absolutely correct area of the whole village, and the whole of the residuary village estate obtained by such means must be wrong[1].

In 1855 Smyth was granted the office of Civil Superintendent of Survey in addition to his duties as professional surveyor, thus giving him control of the Deputy Collectors responsible for boundary settlement, and also of the detailed survey [243, 250–1]. He had complained that the frequent changes of the civil Superintendents, five times in as many years, has had a most baneful effect on the progress. ... It requires an officer to be a certain time in the office before he can make himself acquainted with its duties and the wants of the Surveyor, and this has no sooner been effected...than a change has been made, and a successor appointed who has to learn everything de novo, and perhaps has different ideas and methods of carrying on business to his predecessor [248][2].

He was able to get far better outputs and to effect considerable economy, but the double duties were admittedly too much for one man, and the experiment was not continued after his retirement, though this combination of duties was indeed the normal practice on the Bombay surveys [IV, 239 ; V, 275–6]. Smyth writes ;

The surveyor is enabled to regulate the demarcations so as to dovetail them into his own professional operations. ... He can determine exactly where to send his ameens to prepare ...for ensuing seasons. He can check their work in the field at the time of survey ; he can... improve them in the method of working ; he has all under his eye, and can regulate the professional and civil portions of his establishment so as to prevent...delay to either. ...

The last few years, ... the chief cause of delay to the professional survey...has been the want of a sufficient tract...demarcated ahead, and...the Surveyor is delayed in consequence of disputed boundaries, or want of thaks in the field, or want of the thakbusts themselves. ...

The disadvantages are chiefly that the duties are too much for one hand, and the time and attention of the Surveyor is taken away from his own legitimate duties[3].

In the Punjab there was closer cooperation between the Surveyor and the Settlement Officer ; *khasrah* surveys were essential for settlement purposes and every effort was made to make them as reliable as possible. They were carried out under the Settlement Officers by village *patwāris* who had been first trained by the professional surveyors. The following account is given by the Settlement Officer of the field survey in the Kāngra hills which were triangulated by Blagrave's assistants who fixed the positions of villages and patches of cultivation scattered over the hill sides [271]. The district was divided into circuits, each under a *patwāri* ;

To each circuit were also allotted two men expert at measurements, and each man was provided with a rod of bamboo of...9 cubits, or 4½ yards. This bamboo is technically called a "*kan*". ... The local square measure is a *koomso* of about 3,600 yards. ...

The *kanbans* were usually taken from other pergunnahs. The rate of remuneration was... 6 annas for every 100 *gumaos*, ... half of which was withheld till their work had been tested and approved. The people of the village paid all the charges. ...

The *kan* can be used without handles, and is then wielded by one man only, who walks at a steady...pace to the limits of the field, swinging the kan out before him. In some places the country was so rugged that the kan could not be used. Three double steps, the step taken by the right foot only being counted, were assumed as the equivalent of a kan.

The preparation of an accurate return of all the cultivated and culturable lands was left to the patwaries and lambardars. I experienced no inconvenience from the absence of a regular register. ... When engaged in...attesting the measurements neither the tehseeldar nor myself was ever at a loss to trace in the rude slips of the patwari the identical fields and holdings. ...

The patwari has his writing materials and stands at the corner of the field. The owner runs to point out the limits of his holding. One measurer is employed to ascertain the length, and the other the breadth. ... If the field is of irregular figure the length and breadth are measured at two or three different places, and the average result recorded. ... The calculation is speedily made, and the entire contents of the field are entered in the registery. ... The patwari fills up the other heads of the registery from his own observations. ...

In adopting a system...which is one of the hereditary institutions of the people we provide a most efficient check upon the proceedings. ... The measurers and putwarees are followed by a hundred eyes, and every man looks not only to the careful measurement of his own fields,

[1] *GR. Rev., 1858–61* (154–5), DSG. to SG. [2] DDn. 37/74 (100), Smyth to DSG., 5–6–52. [3] *Rev. Sry. LP., 1855–6* (41), Smyth, 6–12–56.

but...to see that his neighbours are not unduly favoured. ... He will not fail to remember the kans of width and breadth. ... To supersede the local standard by a new and foreign system is not more reasonable than to compute the area of Stowe Park in beegas and biswas[1].

In the plains of the Bari *doāb* the *patwāris* were trained to survey the village boundary, as *hadbast*, with a small planetable described as an

18-inch square board. To this...is fixed a 'quiblanumah', a rough compass used by the Mahomedans to denote the West[2], and chiefly brought from Kashmere, ... procurable in any quantity in the bazar at Umritsur at one rupee each. ... The outer edge of the board is divided into ten-degree sections. The iron sight-rule has perpendicular sights at either end, and is graduated in a scale of kadams [paces]. The cost of these...is Rs. 1–12. ...

The triple-junction points are now fixed by measurement from each other all round the mouza and...equal distribution of any error becomes easy and certain. ... The village thakbust map...is required for constant reference, and is placed in the hand of the European assistant who undertakes the professional survey. ... The putwaree obtains a plot of the boundary completed on the ground, which proves itself, or demonstrates any error[3]. ...

The same apparatus is used for the interior, or field, survey. ... The average rate of progress in this field survey was about 50 goomaos a day. This system, as matured by Messrs. Davies and Blyth, ... is by no means original, as...reference to the Manual of Survey will have shewn. The merit of originating this schemes is chiefly due to Capt. Thuillier[4].

Under Thuillier's guidance there was steady improvement in both professional and *khasrah* survey, but the resulting topographical maps left much to be desired, and the manner in which the *khasrah* survey was carried out without professional control was severely criticised by an experienced Settlement Officer [7]. Markham is particularly severe on the Punjab system ;

The first khasrah survey of the Punjab proved a failure. It was made by planetable to which native-made compasses were attached, which were in the last degree uncertain and confounding. ... In 1856 it was reported that all the work done in this way was utterly useless. ... Since...1863 a great advance is reported to have been made[5].

UNITS OF MEASURE

In 1824 it was ruled that the revenue surveyors of the Upper Provinces should use the English acre of 10 square chains, 4,840 square yards, or the Bengal *bīgha* of 1,600 [III, 164]. In actual practice this was not so easy, for the *amīns* would only work with the local measure to which they were accustomed [299].

Whilst the *bīgha* was one square *jarīb*, and the *jarīb* measured 80 *haths*, or cubits, the length of the *hath* varied from district to district, and even from one *pargana* to another. The measuring rod, *nal*, *luttah*, or *laggi*, or the rope, *rassi*, varied again and might be 5 *haths* in one part of a district and 5½ in another [IV, 208]. Wyatt found that the *laggi* in general use in Sāran District was 7½ *haths*, that in Hājīpur *pargana* in Tirhut was 6 *haths* and of different length again in other *parganas* ;

The length of the luttah or luggee in haths, and the length of the russee or beegah side in feet and inches are always marked on the face or heading of every khasrah missil. ... Iron chains, and not ropes, are used on this survey for the khasrah measurement. ... The chain is made equal to one fourth of the russee, or beegah side, and divided into luggees, or 20th parts of a beegah side. Four of these chains being equal to one russee, the field measurement is expeditiously carried on, and clearly understood by the contract ameens, as well as by the landholders and the village community.

The chains are certainly injured by increasing and decreasing their lengths to suit the different luggees in use, but this is unavoidable[6].

Sherwill reports that in Monghyr there were five different sizes of *bīgha*, so that contracts with *amīns* had to be made out by acre and not by *bīgha*. Two rupees for 100 acres, free of all charge for paper, etc., was a remunerative contract rate. In Shāhābād the *bīgha* had been 3,025 square yards whilst in Monghyr it varied between 3,025 and 4,900.

[1] *Punjab Sel.* I, No. III (32–7). [2] for prayer towards Mecca [IV, 426]. [3] ib. I, 1853, No. VI (73–4); R. H. Davies, SO. Bari *doāb*. [4] Thuillier & Smyth (577), from Barnes, Comnr. Lahore, 113–121–52. [5] Chas. Gubbins ; *NWP. Sel.* II, 1852, XXXI (49, 83, 92) ; Markham (119, 184–5). [6] DLR. 36/27 (19).

In Purnea District there were no less than 39 different measuring rods. On every village plan the length of the local *guz* was entered in English units.

In 1850 the Board of Revenue ordered that the Bengal *bīgha* should be adopted;

> The Bengal beegah of 14,400 square feet is...known so generally that...all classes understand the extent of land which it is intended to represent. When a beegah was made equivalent to an acre in Cuttack the state of things was very different. A beegah in that province was anything between 15,000 and 60,000 square feet, and no two villages had a common standard. ... The Bengal beegah...is for all practical calculations one third of an acre. Three beegah are less than one acre by only 360 square feet[1].

FIELD TESTS

The testing of field work on the ground has always been an important routine on revenue surveys where so much depends on the work of low-paid men [II, 181–2 ; III, 148 ; IV, 448, sv. *partāl*]. Smyth records that

> in my predecessor's time aumeens were sent out to measure villages and were never heard of again until they brought in their measurement papers...and, from being their own masters and uncontrolled from the time the Hooghly survey commenced in 1843–44 up to 1846–7, when I took charge, have ever since been, with few exceptions, uncontrollable. My first step was to call for monthly returns through the purtal aumeens, ... and to require the aumeen on the completion of his measurement to transmit his fieldbook. ...
>
> It is a common practice...for aumeens to come to the office, and on giving in the required security, to receive a village for measurement and, finding it is not one suited to their ideas, either from the locality or otherwise a difficult village to measure, they return the documents... by dak, and leave for their own homes. Other aumeens will not take this village, ... knowing that another individual has thus returned it. ...
>
> The assistants are directed...to survey and partaul one in every 20 villages surveyed, and whenever I travel...I always make a survey by perambulator and bearings on my tour.
>
> Partalling topographical work is most necessary...but there is no duty more objectionable. ... There is still on these surveys the desire in every assistant to give a greater area, and more villages, than his neighbours, which is worthy of commendation, and anything...that interferes with this, such as taking a native surveyor off his work to purtal other...work, ... is looked upon as so much area...lost to the assistant.
>
> The best purtal is a series of lines taken across a pergunnah in different directions, and... plotted on the chudder maps [305]. ... With a perambulator he might with ease ride 4 and 5 miles early in the morning twice a week. ... Each assistant runs a perambulator line from 30 to 40 miles every month, ... not confining himself to...one village only. ... He will keep a fieldbook of his partal, which will contain the different items crossed by the perambulator, intersections and such objects as may come within 8 or 10 chains of each side of his line. ... 200 miles of partal have been executed and though...shewing...that a check does exist, still it interferes very much with the general progress of the work. ...
>
> I propose this season, instead of making each assistant partal his own work, to have a partal party independent of the general work, whose duty it will be to make a continuous partal through the work of the season[2].

FAULTY WORK

It would be difficult to conceive of a more tedious and exhausting occupation than that of a revenue surveyor working through the hot and water-logged plains of Bengal, running endless traverse lines—juggling with uninteresting figures—watching over the labours of a large staff of low-paid measurers—striving to complete several thousand acres during the hottest months of the year before the burst of the full fury of the monsoon—and no retreat to the hills. Work could not all prove correct and exact. We find three notable failures.

In Midnapore District Mathison prided himself on the accuracy of his traverses. When discrepancies were found along his junction with Fitzpatrick's survey the

[1] Report 1849–50, 10–10 50. [2] DLR. 37/72 (100–12) ; Report 1853–4 ; Smyth, 2–10–54.

resurvey showed that the Balasore work was full of mistakes. The young assistant responsible gave excellent reasons why the boundaries traversed differed so widely from those laid down by the civil authorities. In many cases the discrepancy did not involve more than about 5 acres...but "there are others of a very different nature which shew a striking difference, and which materially affect the area". There were disagreements in the names and numbers of the "chaks", or village plots, generally due to insufficient marks on the ground. One village that originally had only 12 recognizable marks, had since been marked by more than 150. In many cases the local people themselves were uncertain of their exact boundaries [IV, 191 ; V, 246–7].

Ivey complained that he had been obliged to employ "new hands drawing only Rs. 7 a month, and just promoted...from the list of khalasis" for the actual measurement. His officer-in-charge, Fitzpatrick, continually pressed for speed. "That there are instances of...neglect on the part of the native surveyors I will not deny, but then the assistants themselves had always their full work with the village calculations". When a defaulter was reported little notice was taken, "the surveyors became saucy to me, and in turn complained of my severity"[1].

Other discrepancies were found right through the Midnapore survey, and John Swiney who was employed on a partial resurvey for three seasons reported that

the inequalities in the areas as recorded by the professional survey and khusrah have arisen sometimes from the incorrectness of one of the measurements only, but more commonly from both, in addition to which the false method...used...for reducing local beegahs into acres has greatly exaggerated the...error. ...

The discrepancies...may be classified under five heads ;

First, when the khusrah is...wrong in the actual measure by the aumeen ; e.g., ... 363 beegahs instead of the true 256.

Second, where the aumeen has neglected to include...lands appertaining to the village. ...

Third, where the Surveyor has adopted an incorrect boundary.

Fourth, where the aumeen has included in one chitta two or more villages under one denomination...and the Surveyor has measured the same singly. ...

Fifth, where the Surveyor has measured two or more villages as one, and the aumeen has measured the same separately. ...

In the professional survey...strict orders had existed that every boundary party must measure between 3 and 400 chains every day. ... He was induced for fear of punishment to hurry on the chain work, paying little or no attention towards the offsets[2].

On this the Revenue Board commented that

the professional map, the khusrah, and Mr. Swiney's revised plans all differ, and the discrepancies do not merely concern incorrect boundaries, but...lands have been to a great extent wrongly allotted. ... Should any of these records be at any time applied to Revenue and Judicial purposes "something very like total confusion" will ensue[3].

Wilson's survey of Hooghly District was even more disastrous. Here again was a failure to make sure of the exact line of boundary to be surveyed, but there was also a sad lack of supervision, and this continued after moving to the 24-Parganas. The work of three field seasons had to be entirely rejected, the area in the 24-Parganas being resurveyed by Smyth who took over charge in June 1847 [247–8]. Examples of faulty work in Hooghly were the distribution of an angular error of 4° 35' over a length of 7 miles of "what ought to have been a main circuit", and Gunter's chains being found out of length by as much as one link in every chain.

The disasters in Bhāgalpur District during Sherwill's absence on furlough, 1848–9, were due in part to the inexperience of the Civil Superintendent, but still more to that of the military officer in temporary charge of the survey, who was so much occupied with unfamiliar routine in office that he found no time to visit the field camps. A senior assistant in charge of computations covered up the faulty work of measurers and traversers by manipulating figures. This was brought to light by O'Donel who held charge for a few weeks before Sherwill's return, and found errors of 20 chains and 100 degrees in the computation of a traverse circuit.

[1] DLR. 36/39 (44); from Ivey, 25–6–45. [2] DDn. 482 (133, 148), Swiney to DSG., 23–7 & 2–10–47.
[3] DDn. 562 (146), Rev. Bd. to Govt., 11–7–51.

The offending assistants were discharged and the two whole season's work had to be re-surveyed [254–5]. Sherwill attributed the trouble to "three primary causes";

1. The want of an efficient Revenue Surveyor to guide the proceedings.
2. The utter worthlessness of the Persian *thakbust misls* [IV, 205 ; V, 299–300].
3. The insalubrity of the climate which has during the past season alone killed a great number of my efficient men[1].

Without an experienced and efficient officer in charge, no Revenue Survey party could possibly be successful. It was continually urged on Government that it was most important to have at least one young assistant surveyor under training, fit to take over charge of any party in an emergency. Close cooperation between the Revenue officers and Surveyors was also essential.

MAPS

All village maps of the Bengal Presidency were plotted on scale of 4 inches to a mile, and from 1840 most of those of the Lower Provinces had been lithographed for distribution to officials and sale to the public [IV, 206, 209]. In 1847 the Deputy Surveyor General was supplying hand-drawn copies at the rate of Rs. 1/8 for a village not exceeding 1,000 acres—or Rs. 2 if larger—copies being supplied in the first instance to the Revenue officers and to the Deputy Surveyor General bound up together by *parganas*. Many volumes of the fair copies of the North-Western Provinces and the Punjab between 1847 and 1856, have been preserved in excellent condition, and were transferred to the National Archives in 1955. Few of the village maps of the N.W.P. surveys 1823–42, have survived [IV, pl. 12]. Those distributed to Commissioners and Collectors were nearly all destroyed during 1857. Other copies sent down from Allahābād in 1843, reached Calcutta in a useless condition and were destroyed with official sanction [322–3, 483] ;

All the village maps that were sent—eaten away by white ants—...in 23 beer chests in the most admirable state of confusion, have long since been committed to the flames, together with fieldbooks, calculations, etc. ... In the letter which preceded...it was stated that they were of no consequence. ... Many district maps are also missing. ... From one of these beer chests... was withdrawn a large mass of pulpy paper, ... the box having received a wetting by having been placed in the lowest part of the steamer's hold[2].

Thuillier was however, able to report in 1859 that he had made

great exertions...to supply those local officers who...stood in most need of the survey records of their districts, and very considerable progress had already been made towards effecting duplicates of 32,430 village plans and 203 pergana maps destroyed by the rebels, the original of which are fortunately forthcoming in the office[3].

From 1853 the village surveys of the Lower Provinces, being generally too small to be treated individually, were plotted to fill one sheet of paper, a *chaddar* ;

The present system...consists in furnishing...every village or mouza plan drawn on a separate sheet of...paper on the scale of 20 chains to the inch, with a printed statistical register heading for the insertion of area and details of detached lands, together with other statistical data, and on the other side of the page a copy of the traverse and area calculation [IV, pl. 12]. A duplicate copy...is furnished for the Collector's office. ...

In future the village plans are to be congregated on the same scale, shewing as many villages ...as can be conveniently introduced into an Imperial sheet of paper. ... Each sheet must be of an uniform size...called a 'chudder'. This will be lithographed as a Standard Sheet[4]

In the Upper Provinces and the Punjab the country was sufficiently open for the *pargana* maps to be drawn on the ½-inch scale, though in many areas the ½-inch district maps showed so little topographical detail that the N.W.P. Government preferred using the *pargana* maps after they had been filled in by local district officers [313].

In the Lower Provinces *pargana* maps had to be on the one-inch scale owing to the congested character of the country and, writes Thuillier,

[1] DLR. 37/63 (228), to DSG., 15–11–49. [2] *Rev. Bd. WP.*, 27–6–43 ; DDn. 553 (6), from DSG., 27–5–52: [3] *GR. Rev. 1857–61* ; DSG., 2–4–59. [4] DDn. 623 ; co., 3–12–55.

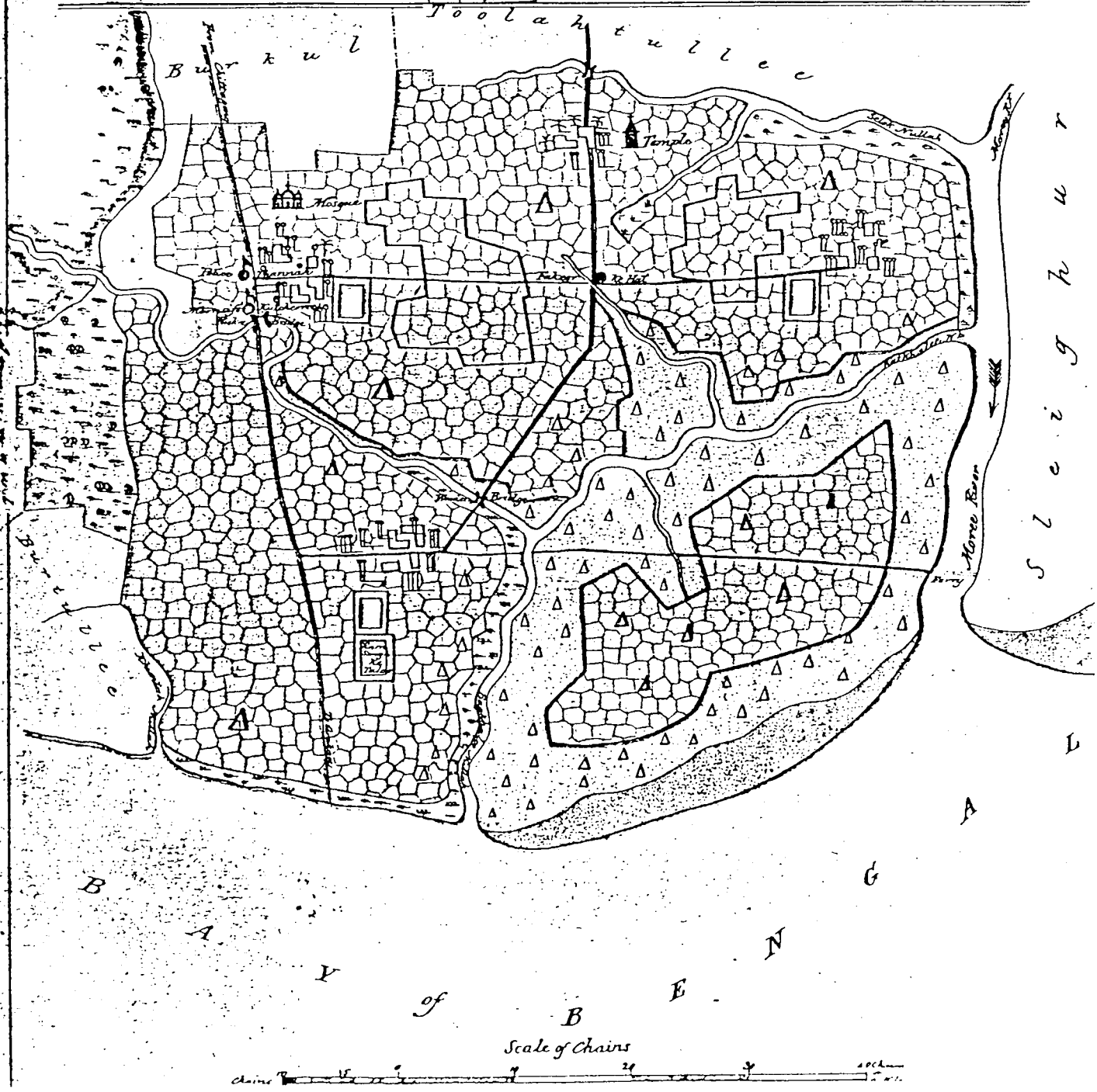
PLAN of Mouza Silkop Zillah Chittagong

Reduced from 12-inch village plan surveyed during 1847 by John Kelso, Assistant Revenue Surveyor.

This village fell in the salt agency of Bhulua, now part of Noākhāli District, north of Chittagong.

References.

- Lowlands yielding two crops of rice
- High do do one crops of do
- Houses or Huts
- Hills and Jungle
- Cultivable Waste
- Barren Waste
- Salt Waste with positions of the Barrahs
- High or Pak Road
- Village path
- Rivers and Nallahs
- Sand-bank
- Tanks
- Marsh or Theel
- Betelnut Trees



Scale of Chains

The pergunnah maps form the groundwork of the district and division maps...constructed in this office and, being the only general maps required from Surveyors, it is essential that they should be strictly accurate as to village boundaries, as well as all other geographical details. ... These original maps...being intended for lithography...should be as complete as possible in themselves, so that they may be sent to the press as soon as possible[1].

From 1855, following the success of the *chaddar* plans, and on account of the disconnected nature of the *pargana* boundaries, these one-inch maps took the form of "main circuit maps" [298] which were

lithographed precisely as...received from the Surveyors, ... thus, by having the lithographic press under my own superintendence, an immense amount of labour is saved to the drawing branch [354]. For the Punjab and N.W.P., however, where the unit of survey is so much larger, averaging upwards of a square mile, the districts are susceptible of compilation on the scale of 2 miles to the inch, ... sufficiently perspicuous to shew the village boundaries. ...

The publication of so many maps involves an immense amount of colouring work, and the demand for them by private individuals has caused large business to spring up, for which my slender establishment is in no way competent. The sale of maps, involving heavy money transactions, issue of bills and receipts, and a considerable correspondence, has now been transferred to the booksellers of Calcutta [323].

Since 1852–53, the following is a summary of compilation ; 4 miles to inch, Bengal, N.W.P., and Punjab districts, 13 maps—2 m. to inch, Daman-i-Koh and 9 Punjab districts, 10 maps—1 m. to inch, 24-Parganas and Assam, 6 maps. ...

'Owing to the extreme intricacy of the fiscal tenures in East Bengal, the main circuits...are made in compact and convenient blocks without reference to the limits of the pergunnahs, ... and the village survey on the 20 chains = 1-inch is rendered on uniform imperial size sheets, ... bound up into strong and convenient atlas. ... A new edition of the Behar districts on the scale of 2 miles to an inch has been commenced exhibiting the re-adjusted civil and criminal jurisdictions, and Tirhut has been published [257][2].

The preparation of quarter-inch maps in the form of district maps, and for the Atlas of India, is described in the following chapter [312–5].

[1] DDn. 623, co., 1–6–50 [2] DDn. 624 (7), DSG. to SG., 5–4–56 ; *GR Rev. LP. 1855–6* (17–8), from SG., 1–2–57.

CHAPTER XIX

MAPS

General Maps of India[1] — *Atlas of India* — *Assam & N.E. Frontier* — *Bengal & Upper Provinces* — *Central India & Rājputāna* — *Punjab & North-West Frontier* — *Himālayan Areas* — *South India* — *Map Drawing* — *Orthography* — *Custody & Distribution.*

DURING Everest's time the drawing office at Calcutta was fully occupied in working up current and recent surveys into suitable shape for the quarter-inch Atlas that was being compiled and engraved by John Walker in London, and in producing small-scale maps of important areas [IV, 286–96]. The preparation of general maps of India was left to European publishers of whom the best known were John Arrowsmith, W. H. Allen, and James Wyld [IV, 304–5].

Allen's revised 64-mile map, engraved by Walker and published in 1845 was welcomed by the Asiatic Society as "the most complete at present procurable"[2]. Walker's New & Improved *Map of India* on scale 32 miles to the inch followed in 1852. Both had been officially supplied with material by the Court of Directors[3]. In 1862, Walker tells the Surveyor General of his troubles ;

I am correcting my Map of India. ... I did it originally for the House of Commons and the East India Company. Each agreed to pay half the expenses, but when it was finished they backed out and left it upon my hands, when I was glad to sell the copyright to Messrs. Allen, because I found that other map sellers were pirating it in all directions. Not being in the "trade" I find it is a bad speculation to publish on my own account[4].

Though, "under the orders of the Hon'ble Court of Directors", the Surveyor General was "prohibited from publishing any geographical materials whatever"[5], Waugh had skeleton maps printed on scales 48 and 64 miles to the inch for various official purposes, and these were periodically brought up to date[6]. Of two 64-mile maps of 1844 one shewed the lay-out of Atlas sheets and progress of surveys, and the other the districts of India [IV, pl. 3][7].

A lithographed 103-mile map of 1847 shewing British territory and "Native States" [IV, pl. 23], was prepared on a request from Government for "an estimate of the superficial area of the British possessions and those of the Native Chiefs in India, as well as one shewing the entire length of frontier from the sea-coast of Sind on the west to Singapore on the east"[8]. The Surveyor General passed this to Thuillier pointing out that

it is only by a computation of each separate district that the aggregate area can be arrived at with any pretension to accuracy. ... The areas of the districts which have been measured by the Revenue Survey are immediately available, ... but the areas of unsurveyed tracts can only be measured on the map by inscribing within each figure a large square or rectangle, and dividing the outlying portions...into small squares. ...

It has been proposed before now...to ascertain areas by weighing the paper covered by a map and comparing this weight with that of a rectangular piece of the same...paper containing a definite area in miles. This plan was strongly advocated by the late James Prinsep [III, 495], who had great faith in the delicate power of his scales [at the Mint]. ...

All that is requisite...is to prepare on good paper of uniform texture an outline map of India, with the boundaries of the several districts, provinces, presidencies, etc., duly delineated. The paper...should have its edges cut very accurately into a rectangle of known dimensions. ...

[1] of 1830–60, *IO Cat.* (86–8). [2] *JASB.* XIV, 1845, Progs., 13-5-45 (xl-xli. xcvii) ; *IO. Cat.* (88). [3] DDn. 554 (7), DSG. to Mil. Dept., 15–3–55. [4] DDn. 30 (1171), 10–9–62 ; Markham (407). [5] DDn. 557 (100), SG. to DSG., 20–3–51. [6] MRIO. 95 (1), Mil. Stns., 64 m., 1856. [7] MRIO. 95 (12–4, 19), 96 (3). [8] DDn. 461 (255), to SG., 19–8–47 ; paras. 3–6.

Let this be weighed in the very delicate scales at the Mint, whereby we shall obtain the ratio of weight of paper to area. Now let all the superfluous paper in the outline map be cut carefully away, and the remainder...will give the weight, and consequently the area, ... of all India.

The boundary map was then to be dissected and the pieces weighed separately; A comparison of the results...with the values given by the Revenue Survey will shew what degree of confidence the process of weighing is entitled to. ... I am not aware that it has ever been fairly tested. ... It cannot fail to give very good approximate results[1].

Thuillier carried out this experiment with the new 103-mile map "by the kind aid of Dr. O'Shaughnessy of the Mint"[2];

Considerable difficulty has been experienced in defining...the extent of the Native States, the records of this office not affording the information. ... To lay down the separate Governments is also quite impracticable, and to divide the Native States into chiefships equally so. To give any estimate of area...would require the accurate compilation of a Map of India on a very considerable scale. ... The materials in this office are not comprehensive enough to admit of this, two attempts having already been made without success.

His preliminary estimate of the length of the British frontiers came to 11,260 linear miles including coast-line, whilst the total area of British territory came to 722,758 square miles and of "Native States" to 586,442. The two calculations by weight of paper were made a fortnight apart, the first after very heavy rain, and "the latter...unusually dry"[3]. The difference between the two results was just over 2 per cent. The Surveyor General reported in 1850 that

the total area of British India as it now stands, including Scinde, Punjab, Jullundhur doab, Tenasserim, has been carefully estimated at 800,758 square miles, and Native States at 508,442, making a grand total of 1,309,200 sq. m., as the area under my charge to be surveyed[4].

In 1857 he asked that a General Map of India should be compiled to shew British territory as it was in 1860, and Thuillier replied that

a map on the scale of 32 miles to the inch—the same as Walker's last (1852)...would probably suffice. This map measures 5½ feet by 6½ feet, and embraces all the latest acquisitions including Pegu and Sindh, between the meridians of 66° to 100° of longitude and the parallels of 5° to 36° of latitude. ... The territorial sub-divisions can be well shewn on this scale, as well as the triangulation if deemed necessary. ...

There are...many parts of India where we are almost destitute of topographical materials ...as in the South-West Frontier Agency, or Chota Nagpore country [184], also in sections 90, 91, 92 and 93 [pl. 28]. Eastern Bengal, ... beyond the meridian of Calcutta, is to a great extent still unsurveyed, and in nearly the whole of Assam materials are utterly worthless [311–12]. ... Extense blanks...are also apparent on the Index Map...lithographed here in 1855. ...

Several Maps of India...have been commenced in this office in former years, but none ever came to maturity [III, 285]. ... A small index Map of India, scale 64 miles to the inch, has been in hand for a long time past, attempting to shew the Political relations, and sub-divided into districts, intended to be lithographed for general purposes. ... Considerable progress has been made, but many difficulties occur in completing it. All the British Districts of the three Presidencies have been inserted, but the Native States cause trouble and doubt.

This map shows how very difficult it is to get any complete map of the whole of India out of hand with the means at our disposal[5].

This was the inception of the 32-mile engraved Map of India which eventually became the standard wall map of the Department[6]. Nothing was done at the time, and the Surveyor General wrote again in 1860 asking that

the new general Map of India...may be taken in hand immediately, and all possible means be brought to bear upon it. When I was at Allahabad in 1844–45 [336] the Chief Computer... prepared a set of tables for the projection of this map on the system of conical projection employed in all great imperial surveys. Thus nearly 16 years ago I contemplated the preparation of a final Map of India previous to my relinquishing my command. This projection should now be employed. The scale...to be 32 miles to the inch, in 4...sections[7].

He directed that it should embrace materials up to the end of 1860

defining the progress achieved to the termination of my career. ... I intended all old materials to be superseded when new and final surveys had been made, and where nothing new and superior had been done, the existing information would remain. ... The map should be a

[1] DDn. 473 (28-32), 7-9-47. [2] Sir Wm. Brooke O'Shaughnessy (1809–89); *DNB.*; *DIB.*; no. Telegraphs 1853. [3] DDn. 472 (241–3), DSG. to SG., 11-11-47. [4] *PR.* (15). [5] DDn. 663 (281), 13-11-57. [6] *GR. Topo., 1876–7* (9). [7] DDn. 666 (194), 2-10-60; six sections eventually.

new Map of India, up-to-date. ... To make a...complete map of India with accurate materials is impossible at the present time, but the extent of accurate survey and of new geographical materials is immense. ... If the advantage of successive editions is recognized, and a date fixed for the map, ... the technical difficulties vanish[1].

By 1870 five of the six sheets were well advanced, No. 2 to the north-east having been left to the last. Reduction had also been made by photography, and engraving started, of a new 64-mile map, of which a preliminary edition without hills was published in January 1877 and was in great demand[2].

A Map of India, scale 128 miles to the inch, with hills, was engraved in 1864 and was later used as basis of the diagrams of the G.T.S. [pls. 4, 5][3].

ATLAS OF INDIA

The quarter-inch Atlas of India had been introduced as the standard map of India by order of the Court of Directors in 1823 [III, 282–6]. The engraving was carried out in London by John Walker, and the first 24 sheets were published by James Horsburgh, the Company's Hydrographer who died in 1833 [III, 462]. Full responsibility then passed to Walker who succeeded as Geographer. Material was sent from India on the quarter-inch scale, and was only accepted if based on, or connected to, the Great Trigonometrical Survey, and ruled up with lines of latitude and longitude [IV, 303].

By 1843 forty sheets had been published and by 1861 this number was increased to 61 with revised editions of several of the earlier sheets[4] [314 ; pl. 28]. It was the official policy that the Atlas sheets should meet all map demands, and submission of suitable material to London, together with complete and final trigonometrical data, was the first duty of the Calcutta drawing office [IV, 295]; there was, however, so long a lag between the completion of a survey and the arrival of the corresponding Atlas sheet that urgent calls for preliminary maps could hardly be resisted. The Directors write in 1845 ;

The triangulation of the Gora meridian, as well as that of Kararah and Gurwanee, should be sent to us as soon as possible ; also all routes and other local surveys for the completion of the sheets of the Atlas which come within the area of these meridians[5].

Our Geographer is at present engaged on sheets 49, 50, 51, 52, 67, 68, 69 and 70 [pl. 28], ...several of which are taken from the district surveys on the scale of 4 miles to an inch, as executed by order of the Sudder Board of Revenue [IV, 289 ; V, 312], and...adjusted by the triangulation of the Meridional [Great] Arc, of the Budhon, Rangir, and Amua meridians, and of the Longitudinal [Calcutta] series. We desire...two sets of the district surveys...as far as...they have been lithographed [312–4]. ... All routes and other partial surveys of the Saugor and Nerbudda Territories not heretofore forwarded to us may be sent as soon as possible[6].

In passing these orders to Wroughton the Surveyor General commented that the western part of sheet 50 will...be found rather barren of details. In the direction of Alwar surveys were made a few years ago by the Quarter Master General's Department which might be...combined by means of the G.T. operations. ... Some local surveys were also carried on under the orders of the Military Board about ten years ago for...irrigation of the country between Alwar and Bharatpore. ... Your own beautifully executed surveys of Muttra, Agra, etc., will form valuable materials for the eastern portion [IV, 222]. ...

Sheets 51 and 52 are included in the map of Gwalior of which a new compilation was in progress...when I left Calcutta [315]. The new high road from Agra to Bombay, surveyed by...Major Drummond [III, 440], and since carried on by Lieut. Abercrombie, ought to form an important feature in these sheets [IV, 269–70 ; V, 126][7]. ...

The Superintending Engineer of the N.W. Provinces has lately been...compiling a map of roads and, as most of these have been constructed since the surveys of the N.W. Provinces were made, ... a copy...should...be prepared for transmission to the India House. ...

[1] DDn. 4 (335), 21-12-60. [2] *GR. Topo., 1869-70* (XX); *1871-2* (8); *1876-7* (9). [3] printed 1874 for *GTS.* III, and VII. [4] DDn. 6 (31-3), SG. to Mil. Dept., 22-5-61 ; list of 41 sheets available and 13 expected, *PR.* (44-5) 2-4-51 ; *IO Cat.* (81-3); Index, Markham (406). [5] v. MRIO. 15 (3), 30-mile strip along Gurwāni Series [*12, 103*]. [6] CD. to B., Mil., 14-5-45 (32); DDn. 624 (104-17), from DSG., 5-4-56, work of DO. 1853-5. [7] BM. Maps, 2. b. 38, Agra-Bombay road, ½-inch scale ; SGO. Calcutta, 1851.

It is very evident from...the Hon'ble Court's letter...that they desire the Trigonometrical Survey to form the basis, and the Revenue Surveys...the details, of the Great Indian Atlas [III, 194 ; IV, 288–90]. ... In no other way can the country be surveyed in a respectable manner [IV, 303]. ...

With respect to the...revenue survey district maps...you should report specifically on the merits of each. ... Without information of this kind it will be difficult for the Hon'ble Company's Geographer to reconcile...the discrepancies which always appear...whenever surveys...by different surveyors come to be united together [IV, 289–90 ; V, 245, 294]. Your professional comments...will be...highly appreciated[1].

It was now Wroughton's task to compile the revenue surveys into quarter-inch district maps adjusted to G.T.S. control, and to have them lithographed either at Calcutta or London, and passed to India House for incorporation into the Atlas [IV, 289–90 ; V, 312–3]. Other material, some from the Madras and Bombay presidencies, was less reliable but writes Waugh, good enough for filling up blank spaces.

For sheets 51 and 52...comprising the Gwalior State a compilation was commenced when I first took charge, ... using such geographical materials as were available, but these were of the lowest order, consisting chiefly of route surveys by officers of the Quarter Master General's Department and itinerary surveys of travellers. The Great Arc series...enabled the compiler to correct the positions of...places lying 30 miles to the east and west, ... but the whole tract...—Jodhpur to the north-west—Baroch to the south-west—and the meridian 77° to the east, ... is of the same value as the map of Malwa compiled...in 1820 under...Sir John Malcolm [III, 84–6]. This compilation can therefore by no means be...final. ...

The map is in one respect valuable as fulfilling a temporary purpose, and might be used as a first edition until superseded by more accurate surveys. ... I have directed the map to be sent home together with all the other compilations of similar character...from old military routes, ... especially of such parts...which are not likely soon to come under...regular survey. ... New editions of the Atlas sheets can always be substituted as better materials become available. ...

I would...solicit the orders of the Hon'ble Court regarding...the remaining Native States without a regular survey of which a great number of sheets of the Atlas must remain nearly blank. ... Those sheets in which our regular revenue districts are comprised will be speedily and satisfactorily filled up, ... but the territories belonging to native chiefs which...are all more or less wild, hilly, and covered with jungle, will not come under the operations of the Revenue Survey...at all, and their delineation must therefore be separately provided for. ...

The best plan would be to take up the details on the same principle as the Madras topographical survey, but on the smaller scale of ½-inch per mile, which would be quite sufficient...for military and political purposes, while it would admit of greater rapidity of execution [289]. ... We may either wait until...the Great Trigonometrical Survey has been advanced sufficiently to enable one or two parties—now engaged upon great series—to be employed...in taking up detail, ... or a special topographical party...may be organized. ...

We are making rapid strides towards the completion of the most important sheets of the Atlas which have been the scene of regular survey. ... With regard to those territories that have never formed the scene of regular survey, ... geographical information must depend on such materials as Quarter Master General's routes, the surveys of Engineer officers, ... Political Officers, and Boundary Commissioners, all of which...are placed entirely beyond the control of this Department[2] [IV, 295–6].

In 1859 Thuillier complained of the great delay between the despatch of material from India and the arrival of the engraved Atlas sheets ;

In consequence of the frequent demands from district officers for maps for which only originals exist, and the increasing necessity for supplying maps of all parts of this Presidency owing to the military...operations caused by the late mutinies, ... the amount of work to be done in manuscript in this office has of late been greatly on the increase [320–1]. ...

A great deal of the labour and expense...might be saved if the materials annually despatched from this office were within a reasonable time incorporated into the sheets of the Indian Atlas, and the engraved sheets returned to this country. ...

When the originals would fill only half or a portion of a sheet, the Atlas sheets need not ...be detained for indefinite periods, ... but the materials furnished might with ease be engraved, leaving the remainder of the sheet to be filled up hereafter by a second edition. ...

Of the 14 degree sheets of the topographical survey of the Himalayas sent to England in 1854, one Atlas sheet, only No. 47, has been returned, and that very recently. If...Nos. 46, and

[1] DDn. 473 (49–52), SG. to DSG. ,31-7-45. [2] DDn. 462 (321-32), SG. to Mil. Dept., 13–6–49.

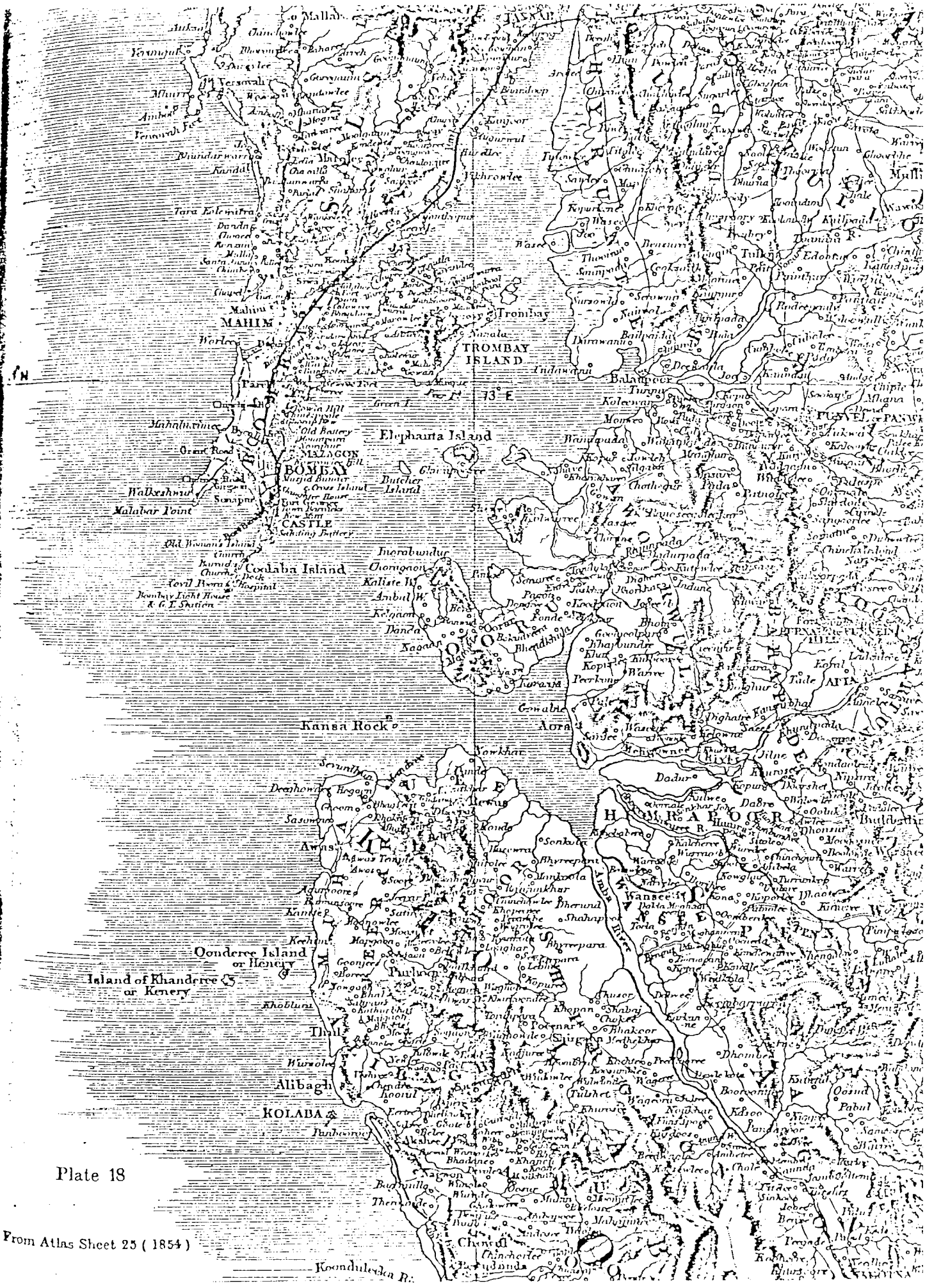


Plate 18

From Atlas Sheet 25 (1854)


Plate 19
from Atlas Sheet 43
of 1827
COORG
MUDDUKAYAY

revised editions of 48, 65 and 66, which embrace this survey could be supplied in the same beautiful style without...delay it would be of infinite advantage to public service [319]. ...

Sheets 113, 120 and 121...would also be of immense service as the railways emanating from the Presidency are to extend over the districts embraced in these sheets, and the constant demands of the railway officials and contractors for maps of these parts have nearly exhausted the supply of lithographed district maps kept in this Department [323]. ...

Sheets 114, 115 and 116, containing the districts of Bankura, Midnapore, Balasore, Cuttack, Pooree, very long since surveyed [IV, 185–91], and portions of the S.W. Frontier Agency and Independent States, are also a great desideratum[1].

He returned to the attack after succeeding as Surveyor General ;

The degree sections of Colonel Waugh's topographical survey of the Himalayas, transmitted home in 1854, not having been returned within a reasonable time, one Atlas sheet only having been received back in 1859, induced the late Surveyor General to direct me to attempt the lithography of these most intricate maps [318–9]. ...

The map of the Trans-Indus frontier...contains the best and only information we are ever likely to possess for Atlas sheets Nos. 4 and 14, ... inhabited by wild and inhospitable tribes never likely to allow any of our officers to penetrate further than has already been done [219]. ... Half-filled Atlas sheets ought to be issued as they are, instead of locking up important surveys waiting completion of remainder of the sheet indefinitely.

Sheets 104 and 114 which have lately come out answer to the above description. The regulation districts of Western Bengal and Behar which have long since been surveyed are shewn in full detail, ... whilst the non-regulation districts of Hazaribaug and Chota Nagpur, the survey of which has yet to be made, and will occupy several years, are left in blank outline and styled "unsurveyed". These sheets have proved invaluable. ... I would extend this principle for sheet No. 121, shewing the country round the metropolis. ... It is remarkable that the vicinity of Calcutta should have been left so many years without the means of publishing so very important and much-sought-after a sheet of the Atlas. ...

The progress of the Geological Survey of India, of the various Indian railways, and the additional interest in tea, indigo, and cotton, besides the demands of Government officials, railway contractors, private speculators, and travellers, for good maps, ... render it incumbent on me to beg that...the labours of this Department may be made quickly available[2].

To meet these complaints the Atlas was from 1864 engraved and issued in quarter sheets, some by Malby & Sons, and from 1869 the compilation and engraving were transferred to the Surveyor General's office in Calcutta[3].

A full history of the Atlas is given in Markham's *Memoir* which includes a memorandum by General Walker describing the projection used, and the arrangements made for the transfer to India[4]. By 1868 the engraving of 84 sheets had been completed in England. These were all magnificent examples of map-engraving, but suffered from the disadvantages of the single printing in black[5]. In the densely populated areas far too many names were inserted, and in mountainous region the hill drawing was too minute and heavy, and the lettering obscured [IV, 304]. Specimens have been included in this volume, that showing part of Coorg being taken from a first edition of 1827 [pls. 7, 11, 19, 20].

In 1891 the whole series as then published was issued from the Surveyor General's Office at Calcutta in four handsomely bound folios, containing an index on scale 96 miles to the inch[6]. Publication of the Atlas was superseded in 1905 by the adoption of quarter-inch degree sheets.

ASSAM & N.E. FRONTIER

It was a long time before any better maps could be provided for Assam than those compiled from the route surveys of the North-East Frontier by Wilcox and Pemberton [III, 64, 86]. The Agent to the Governor General, Francis Jenkins [IV, 449], had in his younger days contributed to these route surveys, and in 1853,

[1] DDn. 668 (186), DSG. to Mil. Dept., 20–9–59. [2] DDn. 21 (75), 22–5–61, SG. to Mil. Dept. [3] as arranged by SG. on duty in England ; DDn. 102 (48), 8–9–68. [4] Markham (405–9 ; 431–8) ; also Eur. Letters, I (73). [5] coloured boundary ribands were added by hand. [6] Regr. No. 619 ; STD. Nov. 1891 ; (index engvd. 1863 ; 2nd edn. Jan. 1870) 550 copies ; RAI. Lib. ; list of 131 sheets pub. 1877, *IO Cat.* (81–3).

in answer to his request for a map of the Garo Hills, Thuillier replied that he had commenced to throw all the available materials together, ... the old surveys of Captains Schalch and Fisher [III, 49, 144–5], Lieut. Sale and Dr. Hooker in the Cossyah Hills, [183, 186] and the more recent operations of Mr. Kelso in Goalpara [242]. ... I am anxious for...all information...for...the Great Trigonometrical Survey [29][1].

[again three years later] Good and complete materials do not exist. ... These districts, with the exception of Goalpara, were measured merely by khusrah ameens, every village based on its own magnetic meridian, and differing by tens and even hundreds of chains. In many attempts at a compilation...they exhibited such large discrepancies and fictitious boundaries as not to admit of easy amalgamation [IV, 202–4]. ...

Until the triangulation is carried through the valley it will be in vain to attempt any general map of the Province. ... We have no fixed data whatever to guide us. The true position of Gowhatty might possibly be...obtained from the G.T. Survey, ... but there will still be five and a half degrees longitude to be spanned without a single...correct position to keep us in check. ... If the several rough district maps be tacked on one to another for 330 miles of longitude, the error...will not be less than 6 or 8 miles of latitude and perhaps 10 or 15 minutes of longitude. ... This map would have to be lithographed and sold to the public. ... The reputation of the Surveyor General's Department would be compromised by such an attempt[2].

Later as Surveyor General he still had no complete map of Assam ;

Tassin's map of 1840[3] is the only one extant, and I could not produce a better one at present. A general Map of Assam, scale 8 miles to the inch, shewing the roads and prepared in the P.W. Dept. was lithographed at your request only in 1859. ...

The Dacca and Chittagong divisions are likewise very difficult owing to the absence of surveys, but I am using my utmost endeavours to produce skeleton maps of these with such inaccurate and incomplete materials as we have. As soon as the Rajshahee Division, now undergoing transfer to the stone, is finished, one of the above will be proceeded with[4].

BENGAL & UPPER PROVINCES

In Everest's time the urgent demand for maps had been partly met by the compilation of rough maps on the 8-mile scale without any trigonometrical control [IV, 285–8], and a map of the North-Western Provinces had been compiled in 1836, in two sheets, on the 16-mile scale [IV, 287, pls. 3, 11]. These maps were never printed ; copies were taken by hand as called for.

Soon after taking over as Surveyor General, Waugh took steps to have the revenue survey maps made fit for the quarter-inch Atlas. He gave orders for their close connection with the Great Trigonometrical Survey whether completed, in progress, or projected [9, 22, 120, 295–6], and Wroughton pushed on the quarter-inch reductions and compilations from the surveys of the North-Western Provinces, Bihār, and Bengal [IV, 288–90] which were urgently needed to replace the ancient maps of Rennell's *Bengal Atlas* [1 : 227–30] ;

The changes effected by time in the courses of rivers such as the Ganges, the Burhamputur, the Son, the Bhagrutty...—the villages that were in existence in Rennell's time but have since been washed away—have rendered...a resurvey of these provinces a desideratum. Hence the revenue survey now progressing in this fertile tract of British India will furnish the most detailed geographical information that can be desired. By the time this report [of 1850] reaches the India House, the revenue survey will have embraced fully one half of the area of Rennell's Atlas, and probably 10 or 12 years will suffice to complete the...remaining portions of Bengal, that of Orissa and Behar having been already...completed[5].

Wroughton began with the recompilation of the maps of the N.W.P. districts which the Revenue Board had printed at Allahābād [IV, 288–9][6] ;

These maps comprehend the entire extent of country measured, ... the survey of which commenced in 1822 and terminated in 1842, comprising 34 districts, covering an approximate area of 100,000 square miles. The materials...are for the most part forthcoming in the Surveyor General's office, and others exist with the District officers. ... 18 original maps are immediately

[1] DDn. 555 (16), 28–1–53. [2] DDn. 662 (227) ; 704 (40), 19–4–& 1–6–56. [3] Map of Upper Assam, *10 Cat.* (298). [4] DDn. 21 (80), to FWD. 22–5–61. [5] FR. (36) ; Waugh, 20–10–50 ; DDn. 542 (166). [6] *10 Col.* (165–6, 206–7), Atlas of NWP. Settlement maps, litho. ; (208), 16-m. Index, 1845–51.

at hand. ... Ten maps are imperfect, several portions being deficient ; ... having undergone considerable alterations...they must be recompiled ; ... and finally 6 maps are altogether deficient, which must be reconstructed from materials to be obtained from the district officers.

He engaged nine extra draughtsmen, since out of the maps printed by the North-West Board of Revenue, ... Moradabad and Cawnpore districts are so inaccurate and illegible that they could not...be rendered available. ... I recommend that the whole of the N.W. districts be re-lithographed under my superintendence at the Government Lithographic Press [325]. 100 copies can be retained for the Government use, and the remaining copies be disposed of to the public at...4 rupees a copy. ...

Under General Orders of 23rd May last I was allowed an establishment for...compiling, lithographing, and colouring the district maps...comprehending no less than 48 districts. ... Six...are already...distributed—two...are now printing—...two...are ready to be submitted to the press—while the maps of...Shahabad, Sarun, Champarun, Purneeah, and Hoogli, are in process. ... Thus...every district in the Lower Provinces will come under survey, so that...the map department of the lithographic press will have full occupation for a very long time[1].

The N.W.P. district maps were completed by May 1847 and copies sent to London for the Atlas[2]. It was pointed out later that the longitudes had been wrongly adjusted by 3′ 25″, to agree with the latest value of the longitude of Madras, whereas it was the established order to leave the old value unchanged [IV, 103–4 ; V, 126]. These maps contained so little topographical information [IV, 289] that Thomason, now Lieutenant Governor, pressed for ½-inch maps based on the village and *pargana* maps but filled in by local officers ;

In its present state the map is no use. It does not contain the whole of any one district. ... There are many villages omitted whose maps have not been found. The roads are incorrectly inserted. ... The lithographed district maps are incorrect in many essential respects, incomplete, and of little worth. I have lately received a map of the country around Meerut compiled from the village maps...by...the surveyor attached to the Ganges Canal[3]. ... It has been tested by...triangulation of the G.T.S., ... and is sufficiently correct for all practical purposes.

He asked that after the addition of detail collected from district officers the maps should be put together and lithographed by the Deputy Surveyor General[4], a proposal to which Thuillier protested, asking the Surveyor General that requisitions

should come through the Supreme Government, ... otherwise the Lieut.-Governor is capable by his various calls...to keep the whole Department fully in employ, and...prevent...demands from the Supreme Government...being attended to[5].

His Honour wants the Collectors...to prepare these maps, which...requires the utmost amount of skill of a professional compiler, who should know how to survey also. Now this ...is somewhat similar to asking a carpenter to make a pair of boots, or a shoemaker to construct a mahogany chest of drawers. If His Honour wants these maps with all the minutiæ of detail, ... and...changes...in the boundaries of districts, this can be...best obtained by the reorganization of a Surveyor's compiling office in one of the central stations of the N.W.P. ... But this will cost money. ... If good and trustworthy work be wanted, it must be paid for[6].

A number of these half-inch maps were eventually lithographed after verification of place-names and boundaries by local authorities, and the village boundaries they shewed were particularly appreciated[7].

The district maps of the Lower Provinces went steadily on from the end of 1847, the elements of construction being the numerical data furnished in the main circuit traverses. ... The boundaries...are defined properly prior to survey, and thus the final results...will not be vitiated and rendered almost useless as...in some of the North-West districts by the civil authorities...altering and transposing portions of pergunnahs and villages from one district to another[8].

Each map carried a compilation note [IV, 289–90] ;

No. 45.—Map of the District of Purneah, surveyed by Messrs. J. Fitzpatrick and J. J. Pemberton, Revenue Surveyors 1840 to 1847. Scale 4 British miles to an inch.

Meridians and perpendiculars...drawn on this compilation. Latitudes and longitudes of 23 stations of the G.T. Survey, and...statement of pergunnah areas are also inserted. ...

[1] DDn. 470 (14–7), DSG. to Mil Dept., 21–8–45 ; and sanction, DDn. 468 (39), 5–9–45. [2] DDn. 481 ; B. to CD., 11–5–47 (67–9). [3] Mr. Prowett. [4] *NWP. Sel.* XVIII (313) ; min by LG. 13–2–49 ; DDn. 469 (49–51), 6–4–50 *et seq.* [5] DDn. 555 (2), DSG. to SG., 4–3–51. [6] DDn. 553 (6), DSG. to NWP., 27–5–52. [7] DDn. 563 (73), DSG. to NWP., 23–5–53. [8] DDn. 472 (263–75), DSG. to SG., Nov. 1847 ; 10. Maps. I–AC. 10 ; complete set 4-mile dist. maps, NWP. & Oudh, 1845–51 ; MRIO. M. 572 ; Regr. of ½-inch Maps ; *v.* DDn. 562 (65), 27–5–51.

This district is bounded on the north by Nepal, to the east by Rungpoor, Dinajpoor, and the Malda districts, and to the south-west by that of Bhagulpoor. ... The inflexions of the boundary coincide very satisfactorily, and the direct distances agree, and the bearing...is 40 minutes less on this map than on that of the Bhagulpoor District. ...

Comparison of direct distances with the G.T. Survey plans is impracticable as the series traversing these districts have not received...final corrections, nor have the plans been projected[1].

This Purnea map could not be sent with the 1845 batch for it was dependent on other zillahs not yet surveyed, and as the external boundaries are in a confused state it will be better to retain it pending the adjustment. ... The confusion arises from these Bengal districts not possessing a well-defined and rounded boundary, an evil which must be as embarrassing for fiscal and judicial purposes as it is for...surveying[2] [254].

Thuillier complained bitterly of the frequent alteration of boundaries that constantly threw his precious maps out of date [257];

Since the Mozuffurnagger map was published the southern boundary with Meerut has been altered. It may be within the recollection of His Honour with what labour and difficulty this district map was compiled, and the number of years occupied in completing it [IV ; pl. 13].

The further change...is a matter deeply to be regretted, inasmuch as it forces on the attention the very serious consequences likely to ensue in the construction of general maps of the country. ... One or two editions have already been published of the engraved sheets [of Atlas] in addition to three editions of the lithographed maps of the N.W.P. districts, and...the boundaries are constantly in a state of mutation even now[3].

A skeleton map of Oudh was in hand and Waugh informed the Resident that the map furnished to your office in 1832 was compiled from old route surveys along the chief roads, ... the geographical lines being dependent on the slender basis of a few astronomical observations with navigation instruments. ... The operations of the G.T. Survey have been extended over a considerable part of the Kingdom, whereby skeleton triangles have been established along 3 meridians, one degree of longitude apart, as well as a longitudinal series in the terai, or north frontier. ... These operations...supply the means of rectifying the old route surveys, while at the same time some additional topographical information has been collected by the parties employed on the great triangles [pl. 4].

He suggested that the Oudh Government might themselves fill in the topographical detail, at a possible cost of about ₹ 5 a square mile, a task of some seven years, but the suggestion was not taken up[4]. Strip maps on the 8-mile scale were, however, prepared for the purposes of the Atlas, about 30 miles wide astride the meridional series shewing detail picked up by the G.T.S. surveyors [103, 119, 184][5].

In 1851 Thuillier sent up for inspection by the Lieutenant Governor an Index Map of the Revenue Survey districts in the North-Western Provinces, including the territory of Oudh, corrected by the Great Trigonometrical Survey, ... and compiled in this office from November 1845 to February 1851, on the scale of 16 British miles to one inch.

From the length of time this map has been under preparation it is probable that some of the district boundaries may have been altered [256–7]. It is most desirable that the map should be printed and circulated generally, but...before sending a copy to the press I am desirous of any suggestions...His Honour may favour me with. As regards the Trunk Road we have had great difficulty in deriving authentic information, and even now the actual state of the main lines above Meerut and Delhi is quite unknown in this Department [315]. ...

There is not a single place on this map which is not absolutely fixed in its true position according to the most recent data of the G.T. Survey. ... Lahore, and Umritsar, indeed, are added approximately, but these points lie outside the general map. ...

A similar compilation on the larger scale of 8 miles to the inch is much wanted, ... but with the unceasing and extraordinary demands on the Surveyor General's Office, ... it is almost hopeless attempting such a formidable undertaking[6].

The map was later published in two parts headed—"The North-Western Provinces regulation districts" embodying "the late revision surveys in Rohilcund—...Behar and Western Bengal—...the southern portion very undefined and blank"[7].

During the year of the Mutiny, 1,000 copies of a 3-inch map of Calcutta were lithographed to illustrate a pamphlet of *Instructions for Officers & Troops landing*

[1] DDn. 555 (7), 27-9-51. [2] DDn. 462 (321), SG. to Mil. Dept., 13-6-49. [3] DDn. 563 (73), Report 1851-2, DSG., 23-5-53. [4] DDn. 542 (192), SG. to Resdt. Lucknow, 18-6-51; *IO Cat.* (225), Map of Oudh, 1848. [5] eg. Gurwāni & Karara, MRIO. 15 (3), 28 (18). [6] DDn. (470), 8-3-51; MRIO. 28 (14-7); *IO Cat.* (208). [7] DDn. 663 (281), DSG. to SG., 13-11-57.

at Calcutta[1], besides an 8-mile map of the country along the Grand Trunk Road from Calcutta to Benares for the use of troops marching up country [483][2].

In 1851 a map of the Grand Trunk Road "*from the Karamnassa* [II, 24, n.7] *to the Sutledge*" was compiled by Charles Joseph at the request of the N.W.P. Government as continuation of his *Plan of the Great Trunk Road from Calcutta to Benares* on the ¼-inch scale. He had now resigned from the Survey [324], and the map was printed "as a private job" at the Government Press. It sold to the public @ Rs. 12 a set and the Military Board was glad to take 500 copies at Rs. 3,000. Thuillier reported that "this has occurred entirely against my consent"[3].

During 1859 progress was made on an extension of the map of the Saugor and Nerbudda Territories, and on a new edition of the 16-mile map of the North-Western Provinces. Each was to be lithographed in four sections[4]. To a demand for maps of Chota Nāgpur the Surveyor General replied in 1861 ;

No regular surveys have ever been made of the Chota Nagpur Division, the whole territory estimated at no less than 62,800 sq. miles *terra incognita*. Limits are utterly unknown, and many parts...have never even been traversed by Europeans. The best possible geographical map of the chief portion...has already been published—"Country south of the Ganges, scale 8 miles to inch"—It is a mere skeleton, and it must answer present purposes[5] [184].

A new Postal Map of the Bengal Presidency was prepared as a private job during extra hours by Mr. J. O. N. James, Chief Draftsman, whose bill amounting to Rs. 800 for projection and compilation accompanies it—most carefully compiled. It will, if published, be useful to many Departments of the Government service, and is also likely to be in demand by the public, as the want of such a general map to supersede Tassin's map, now obsolete, has long been felt [IV, 312]. ... Will submit estimate of cost of lithographing it, if required ; this could be done departmentally, if the Survey Department is allowed to put it on sale[6].

CENTRAL INDIA & RĀJPUTĀNA

In 1844 the Resident at Indore asked for a new map of Mālwa, the only map in his possession being an old one which the Quartermaster General, Bombay, declared to be dated from the days of Reynolds and to be "surprisingly accurate" [II, 282-6][7]. The Surveyor General offered to supply an 8-mile reduction from Malcolm's map of 1818–21 [III, 86 ; V, 188], adjusted to the Great Arc, and with the addition of recent surveys by officers of the Q.M.G.'s Department lithographed copies were supplied by October 1847[8]. A similar map of Gwalior was ready by July 1848 but the press was too much engaged to take up the printing, and it was later sent to London for incorporation into the Atlas [309].

In 1856, Thuillier writes of an 8-mile Map of Rājputāna and Adjacent Countries ;

This map, 6 ft. 8 inches by 6 ft. 1 inch, is become rather unwieldy, which was not originally contemplated. ... It has been ten years in hand, frequently suspended on pressure of urgent work. ... The original object...was to throw various detached routes and isolated patches, ... surveyed at different times...into one uniform whole. ... Its completion is not far distant. ... It is proposed to multiply copies by lithography...for Government functionaries who call for *even approximate* geographical information. ...

These topographical materials are for the most part vague and unsatisfactory, and the territorial sub-divisions altogether guess-work, but we are not likely to have anything better for many years to come. ... The triangulation of the Great Western Longitudinal and Arumlia series have upset a good deal of the map [38–9, 55–6 ; pl. 3][9].

By 1858 the map was ready for transfer to stone, having been under compilation...since the year 1846[10]. ... This map...embraces the country between the parallels of 21¾° and 30¼° north latitude, and the meridians of 70° and 78½° east longitude, ...

[1] *GR Rev. LP., 1857–8* ; from DSG., 2–4–59. [2] ib., *1856–7* (24–5) ; from DSG., 1–2–58 ; *IO Cat.* (168, 211), also 64-m. Mil. Map, ib. (94). [3] DDn. 563 (73–5), DSG. to Mil. Bd., 4 & 6–5–53 ; *IO Cat.* (168, 235–6) ; *Ben. Supply. Regr.* 4 (M. 53) ; *Imp. Lib. M & P.* (268, 622) ; BM. Maps 5-c.34. [4] DDn. 668 (335), DSG. to SG., 4–7–60. [5] DDn. 21 (79), to PWD. 27–5–61. [6] *IO Cat.* (166, 169) ; MRIO. 96 (5–10), Postal Maps 32 m. to inch, 1852, 56, 59 ; DDn. 29 (51), 13–5–61, SG. to PMG. [7] DDn. 456 (26–8), Garden, QMG., to Hamilton, Resdt., 8–10–45. [8] *IO Cat.* (264, 267) ; DDn. 460 (218) SG. to DSG., 11–11–47 ; GBO. Lib. D(2), 12-m. to Map of CI. [9] DDn. 624 (117), DSG. to SG., 5–4–56 ; 663 (281), 13–11–57 ; *IO Cat.* (262–3). [10] ib. (258).

including the whole of Scindia's territory. ... The compilation has...been made chiefly from sketches from the Quarter Master General's Department, from information derived from the civil authorities, and a variety of incongruous materials.

At the time of its commencement the Great Arc series formed the basis of the map. All places west...are...considerably out of their true position, and it was found impossible to correct them without upsetting the whole map. ... The map is comprised in eight sections. ... I have thought it advisable to omit the date of compilation. The original specifies 1846 to 1858, but ...it seems to me better not to shew so recent a date [324][1].

The Surveyor General suggested that lithographed copies of this preliminary edition should be distributed in the Quartermaster General's Department so that intelligent military officers...would be able to interpolate all the information wanting in a rapid manner. ... The positions already established...would answer as points of departure and closing, and further accuracy would be obtained by reference to the points of the Gt. Trigl. Survey[2].

PUNJAB & NORTH-WEST FRONTIER

Just before taking over as Surveyor General Waugh directed the compilation for...the Governor General's Agent, North-West Frontier [269], ... of a Map of the country between Kurrachee and Bokhara, ... Baluchistan and the Manasarwar Lake, including Agra, Jodpoor, Kandahar, Kabul, Kashmeer, Ladak, Yarkand, giving all well-ascertained longitudes and latitudes and routes, and...the features of the country as known to us from good authority.

A Map of the country between the Sutlej and Jumna rivers, exhibiting Sukkur, Sirsa, Delhi, ... Kumaoon, ... Amritsur, Lahor, Mooltan, ... and all roads and rivers[3], ...

besides a map on larger scale covering cis-Sutlej districts and states. He suggested later that the immediate needs of the A.G.G. might be met by

copies of the map published by the Hon'ble E.I. Company's Geographer, Mr. Walker, under date 1842, on scale of 22 miles to an inch, and the Map of Kashmir, ... under date 1st November 1842, on a scale of 13¼ miles to an inch. ... It is my intention to construct the new map on a scale of 24 miles to an inch[4].

The first 24-mile map was completed at Calcutta during 1844, and stretched from the Jumna to the Indus between the parallels of Lahore and Agra. The second, lithographed during 1846, covered the whole of the Punjab, Kashmir, and the "Protected Sikh States". To Wroughton's dismay part of this map was pirated by one of his draughtsmen, who had a lithographed map of his own issued before the official one[5] [183, 323–4]. Throughout the Sikh wars this 24-mile map was the best available and, though both Walker and Allen hastened to publish maps[6], Punjab was still an unsurveyed country in 1852 when the Executive Engineer at Lahore was "quite unable to procure a map...of the most ordinary description"[7].

In 1849, Thuillier started on a new map of Punjab & the Adjoining Countries in 8 sheets, scale 16 miles to the inch ;

The lithographed copies of the 1st edition [24-m. scale] having been exhausted, the compilation of this 2nd edition was undertaken immediately...after the battle of Goozerat [21–2–49]. ... Finished in about 3 years and 10 months on 3rd January 1853 ; sent to the Government Lithographic Press, and 500 copies struck off[8].

The map bears a note shewing that it had been prepared from

i. Col. Waugh's route in Punjab, 4 m. to inch [36, 202].
ii. G.T.S. Stations from North-West Longitudinal series.
iii. Route Survey between Ravee and Chenab by Lt.-Col. Arthur Becher, D.Q.M.G. ; 2 m. to inch.
iv. Route to Jallalpoor...via...Dera Ismail Khan, by Lieut. Tucker, D.A.Q.M.G., May 1850[9].
v. Route of Sikh Army, fled Goojrat to Jhelum, ... surveyed from Jhelum town to D.I.K. by Lieut. Tucker. ...
vi. New routes by officers of Mooltan Fd. Force & Punjab circles.
vii. Lieut. Blagrave's survey of Baree Doab, Noorpoor, Kangra, Chamba, etc. [270–3].
viii. Jullundher Doab and Cis-Sutlej States from Revenue Survey [pl. 16].
ix. To south and east of Iskardo, alongside Deodih and Brima mountains [Brāma, 230 n.3] down the Spiti valley, by Capt. Strachey [187]. ...

[1] DDn. 664 (317), DSG. to SG., 28-10-58. [2] DDn. 675 (127), SG. to DSG., 1860. [3] DDn. 452 (75–7), 13–12–43. [4] DDn. 452 (178–80), SG. to FD., 19–9–44. Tassin had pub. a 32-m. map of NWF. in 1838 [IV, 312]. [5] MRIO. 4 (11) ; 11 (1) ; 95 (15–18) ; DDn. 458 (98–9), DSG. to SG., 18–2–46. [6] *IO Cat.* (232). [7] DDn. 480 (110), 20–7–49 ; MRIO. 4 (10) ; 7 (17A). [8] DDn. 624 (104), DSG. to SG. 5–4–56 ; 30 copies to India Ho., April 1854 ; MRIO. 4 (10, 18). [9] MRIO. 12 (32) ; Misc., 13–0–50.

x. Lieut. Walker's survey of North Trans-Indus Frontier...and litho. sketch south of Kohat of limits of British territory [214–7].
xi. Lieut. Robinson's survey of Hazara [208–9].
xii. Boundaries between British territories from Ravee to Jhelum, surveyed by Robinson [209–14]. ...
xiii. Protected Hill States, ... partly from Capt. H. Strachey.
xiv. River Indus and countries to north-west and north, from Vigne's map, pub. by John Walker; Moorcroft & Trebeck's travels, illustrated by Arrowsmith, and Walker's Map of N.W. Frontier.

Commenting on criticisms from Robinson Thuillier records that the map has been cleaned off the stone and a further edition...is not in contemplation, but I hope to prosecute an entire new compilation...from materials derived from actual survey[1]. ...

The old map was got up for a special purpose at a time of emergent necessity, when the demand...was loud. ... This map which, although dated 1854, was commenced to be compiled long before, has served a most useful end. ... The misfortune of making such maps out of nothing, or next to nothing, is that as time rolls by people forget, after elaborate and expensive surveys have been made, ... that the old document was good in its generation, and correct to the extent of information then procurable [t-page][2].

The most important additions to the maps of the north-west came from the surveys of Jhelum and Rāwalpindi, Peshāwar, Derajāt, and Kashmir. Walker completed his Peshāwar survey in 1853, but in 1851 Government had ordered that a preliminary map should be printed off immediately[3]. The Surveyor General had to comply without waiting for the connection to the G.T.S.;

It is unfortunate that the map should be ordered to be lithographed just at the time that the...great triangulation will in a little while enable us to verify the principle positions in the Peshawar District. ... I expect to carry the triangles to Peshawar this season [37, 216]. ...

If the order...is imperative regarding the immediate printing...there will be two courses open; viz., to draw the meridian and parallels according to the approximate positions given in my route map, depending on my observations at Peshawar and Attock [36, 202, 337]. ... The second method would be to lithograph the map without geographical lines. ... The true geographical lines could be interpolated in manuscript hereafter. ... In some quarters...the utility of geographical lines is repudiated, ... but...the Hon'ble Court of Directors reject every chart without meridians and parallels[4] [III, 124; IV, 300, 304; V, 309].

Triangulation reached Peshāwar early in 1852 and Walker's maps were connected up and the last lithographed sheet issued before the end of 1853 [216]. In 1856 a more elaborate Map of the trans-Indus Frontier was completed on the ¼-inch scale[5], compiled chiefly from Lieutenant J. T. Walker's surveys, ... with certain additions along the Indus River to the north-eastward from Lieutenant Robinson's survey of the Hazara District, also from that of his Jhilum and Rawal Pindi sketch map to the south of the Indus River. ...

The Khyber Pass and the country west of Jumrood, and north of the Sufaid Koh have been taken from Colonel Garden's map [III, 450; IV, 283, 292–4][6].

Walker protested that his own survey on the ground should have been given preference over Robinson's sketchy Hazāra work and Thuillier explains the difficulty of combining the two originals, on different scales, with the same symbols representing different details on the different sections[7]. Three years later he reports that the general map of the Peshawar valley, Kohat, Bunnoo, and Hazara, ... scale 4 miles to the inch, is much needed by the civil and military authorities. ... As the impressions long since lithographed...of Major Walker's original sections are now exhausted, I...suggest that a special demand might be made...for this valuable map recently transmitted to the India House[8]. The ¼-inch trans-Indus map was in due course lithographed in London.

In 1861 the fair sheets of Robinson's survey of Jhelum and Rāwalpindi on the one-inch and ¼-inch scales were sent to England to be lithographed, 600 copies of the ¼-inch and 400 each of the eight one-inch sheets. Printed copies of the ¼-inch reached India in 1866 [214][9]. The India Office, however, called on the Surveyor General to justify the expenditure of £1756 for publishing the one-inch sheets, asking for which of the public departments these maps [were] required, and what grounds [existed] for assuming that these maps, each of which would cost at least 11 shillings, could be disposed of to the public in sufficient numbers to realize any considerable portion of the first cost[10].

[1] MRIO. 4 (13–20), 8 sheets, 8-m. scale; *IO Cat.* (233); cf. DDn. 102 (58), SG. to STS., 28–4–70. [2] DDn. 662 (84), DSG. to SG., 11–3–56. [3] MRIO. 8 (22–3), 1-inch; 9 (1), ¼-inch; both ms. 1849–51. [4] DDn. 561 (201) SG. to DSG., 6–10–51. [5] MRIO. 9 (2), 114 (36–41), 1850–4. [6] DDn. 709 (245), DSG. to SG., 18–8–56. [7] DDn. 709 (287), DSG. to SG., 18–11–56. [8] DDn. 642 (390), DSG. to Mil. Dept., 20–9–59. [9] *IO Cat.* (251–3), MRIO. 7 (38), ¼-inch (38); 1-inch. [10] DDn. 5 (251–4), SSI. to B., 31–10–61.

His reply was emphatic ;

Of all the surveys conducted in India it has been customary to publish the maps either on the one-inch or the half-inch scale, and this has been carried out chiefly by my own small lithographic establishment. ... The geographical or ¼-inch maps only have generally been sent to England for publication, chiefly in the form of the general Atlas sheets. ... .

The one-inch sheets of the topographical survey of the kohistan of the Sind Sagor Doab, including...the Salt Range, are so elaborate...that the late Surveyor General caused the work to be brought up under his own eye...at Dehra Dun, ... and cessation from all field work was directed for an entire season. ... It was found impracticable to produce duplicates within a reasonable time, consequently application was made to produce the...copies at home.

No Revenue Survey...could be carried out [285]. ... It becomes...of vital importance to the local authorities to have good maps, and plenty of them, on the largest scale which the survey gives, and...the publication of the one-inch sheets...becomes a matter of pressing necessity.

The national survey of India...is fairly entitled...to be published and issued on...scale... one-inch to the mile, because if it is not...the...original outlay...is...turned to little or no account. The cost of publication of the whole of the one-inch maps is...about one twelfth of the whole...without allowing for...sale of some of the copies. Such a sum...is altogether insignificant in comparison to the first outlay.

Thuillier then quoted Thomas Oldham's request for one-inch maps to facilitate " a careful investigation of the Salt Range and lead to a sound knowledge of the geology of all the North-West Himalayas [144][1] ". The one-inch maps were duly lithographed by John Walker[2].

HIMĀLAYAN AREAS

One of Thuillier's most unsatisfactory jobs was the preparation of a map of Nepāl that was called for in 1855. The only professional materials were the positions of the snow peaks sketched by Charles Crawford in 1802, and fixed by the triangulators in recent years. After consulting Brian Hodgson, Resident from 1833 to 1844, and George Ramsay, Resident in 1855, he reluctantly passed a compilation that "cannot pretend to a geographical performance of even ordinary accuracy or value", and had 50 copies struck off as a "preliminary sketch"[3].

In preparing his map of Kumaun and the Rohilkhand *tarai* [188], Batten was assisted by William Jones [IV, 451], now Executive Engineer at Naini Tāl, who found the local Atlas sheet most misleading in the place-names and

details of...mountains, minor streams, and the position of villages. On all these points most valuable information is to be procured from the civil authorities, Messrs. Strachey[4] and Batten. Indeed, the latter gentleman...appears to possess an intuitive knowledge of the way a hill *ought* to slope, if not always actually of the way it *does* slope.

Lieutenant Henry Strachey during his enterprising journey in 1846 threw together all the materials that he had the means of collecting, ... and Lt. R. Strachey, of Engineers, will... doubtless contribute some valuable information[5] [IV, 419 ; V, 86, 187–8].

The ½-inch topographical survey of the north-west Himālaya carried out between 1848 and 1854, was mapped in fourteen quarter-inch degree sheets [208, 330–1 ; pls. 6, 10][6]. The Surveyor General had been

most anxious that the final fair map should be sent home for publication as early as possible. ... The revenue maps of the trans- and cis-Sutlej districts will be transmitted to England next year, after which your map will lose much of its value as material for compilation in the same sheets of the Atlas. To expedite the preparation of the final fair maps, Mr. W. Scott advises that it should be divided into degree sheets similar to the Bombay degree maps of the Dekhan [IV, 240, 306 ; V, 191 ; pl. 6][7].

These were then reduced and drawn at Dehra Dūn, outline by W. H. Scott, hand-printing by W. C. Bolst, and brush-shaded hills by James Peyton. One

[1] DDn. 21 (177–84), from SG., 22–3–62 ; 46 (6), note by John James, 7–2–62. [2] Markham (407). [3] v. Sketch map, Nepāl, 1855 ; GBO. Lib. D (2) ; DDn. 663 (3), DSG. to SG., 6–1–57, 554 (15), to RD., 17–2–57. [4] John Strachey (1823–1908), BCS. DC. Kumaun ; bro. to Richd. & Henry ; m. Katherine Jane Batten. [5] DDn. 461 (284), min. by Thomason, LG., 6–2–47 ; 465 (27–30), Jones to SG., 17–1–48 ; map fair drawn and litho. Calcutta, 1851 ; DDn. 562 (59), DSG. to SG., 26–6–51. [6] MRIO. 8 (26–42), ms., incl. index and notes ; *IO Cat.* (239). [7] DDn. 591 (138), SG. to Du Vernet, 7–11–51.

set was sent to London for incorporation into the Atlas sheets, whilst a second set was sent to Calcutta to be lithographed in four colours[1] a process that was new to India [329]. The survey was also embodied in John Walker's 16-mile "Map of the Punjab, Western Himalaya, and adjoining parts of Thibet", editions of 1854 and 1859[2].

Very little of the original survey was omitted on the ¼-inch reductions, with the result that drawing and lettering were much too fine and congested. Printing in colours was, moreover, new to the Calcutta office, and much experimental work was involved. By 1859 only one of the engraved Atlas sheets had come out from England, and the Surveyor General, being pressed for maps of Garhwāl, called on Thuillier to press on with his coloured prints which were giving difficulty [330]. Thuillier replied that

> the reproduction of these intricate degree sheets...has had my very best attention for a long time past, and I only regret...that you should have had to repeat your wishes...so often. ... A commencement will be made at once with one of the easiest sheets, ... and the whole resources of the Press...will be put upon it. ... As soon as our first specimen is ready it shall be submitted for your inspection, and...everything practicable...shall be done to produce these degree sheets in a manner worthy of the Department[3].

The full atlas was satisfactorily completed, and despatched from Calcutta early in 1862 and won a prize medal at the London Exhibition of that year [331][4].

Montgomerie's ½-inch *Map of Kashmir*, completed in April 1859 was laid before the Governor General who wrote a personal letter to congratulate the Surveyor General ; "I never saw a more perfect or artist-like production of its kind"[5]. The map won equal commendation in England where it was lithographed in 1861 [238][6]. The more extensive ¼-inch map was completed in January 1861, and taken to England by Waugh on his retirement. 800 copies were lithographed in England, whilst other copies were struck off at Dehra Dūn from the second fair drawing. Other maps followed some years later [239].

SOUTH INDIA

Except as possible material for the Atlas of India, neither Everest nor Waugh were at all interested in maps of Bombay and Madras. Manuscript maps of all Madras districts had been supplied before 1830 [III, 279] and there were also maps on the 16-mile scale. In 1822 Arrowsmith had published his quarter-inch *Atlas of the South Peninsula* in 18 sheets [III, 288] but, since the abolition of the post of Deputy Surveyor General at Madras, responsibility for maps had rested with the Chief Engineer, who was in no position to undertake further compilation [III, 276–9 ; IV, 328].

In 1854, a firm of Madras publishers, Pharoah & Co., published an *Atlas of the Southern Part of India*, containing 27 district maps on 16-mile scale, 13 circār maps of the Nizām's Dominions, 21 maps of towns and cantonments, with a 48-mile *Map of the Peninsula of India*, extending south from Allahābād, compiled in 1854 by Colonel F. H. Scott, Deputy Quartermaster General of the Madras Army. All these maps were engraved by J. & C. Walker, of London[7].

In 1859 the Surveyor General suggested to the Chief Engineer that it might be possible to publish district maps for the whole presidency, on the one-inch or half-inch scale, from the material at Calcutta[8]. This material was, however, much too old to be worth the expense, and the provision of new maps was left for the newly formed Revenue Survey Department [280].

There was a similar dearth of maps in Bombay and Sind, and the few available sheets of the engraved Atlas of India were long out of date.

[1] DDn. 547 (340), SG. to Mil. Dept., 28-6-55 ; 665 (54), to DSG., 14-5-55. [2] *IO Cat.* (232). [3] DDn. 668 (116), DSG. to SG., 17-6-59. [4] *GR Topo. 1859-62* (19), SG., 8-1-62 ; ackd., SSI., 31-5-62 ; DDn. 30 (171), John Walker to SG., 19-9-62. [5] DDn. 675 (101), 18-7-59. [6] *JRGS.*, XXX (clxx). [7] Markham (191, 407–8) ; *IO Cat.* (85, 313) ono. Comp., L-10-4. [8] 655 (425), 18-3-58 ; DDn. 675 (39), SG. to DSG., 13-4-59.

MAP DRAWING

In 1844 the permanent staff of the Calcutta Drawing Office under the Chief Draughtsman, John Graham, numbered 3 East Indian and 10 Indian draughtsmen, whilst any number of extra draughtsmen could be engaged for a particular job and charged on contingent bill. There was a constant call for maps, and the making of manuscript copies had to be strictly controlled. The capacity of the Government Lithographic Press was entirely inadequate, and only fit for the simplest of drawings. There were, however, several private presses [IV, 311–3 ; V, 325].

Copying by hand was, of course, most wasteful and uneconomical. Having given an estimate of Rs. 1,440 from a private press for printing 150 copies of the Gwalior map [315], Thuillier reported that for the same sum he would get only 6 or 7 hand-made copies, and that a single copy would take a full six months to draw[1]. He refused to take up special work without definite orders from the Surveyor General or the Supreme Government [313].

An outstanding feature of the early maps had been the beauty of the hand-printing, but the low standard of handwriting in angle-books and field work was a constant anxiety to the Surveyor General, who lamented the poor craftsmanship of the average assistant, and called on Thuillier to produce a plate of specimens ;

> Good, clear, neat, clean handwriting is so valuable in the affairs of life that no greater boon can be conferred on a young man than teaching him good habits of writing. ... Appropriate copies of examples in penmanship are crying wants. ... To lithograph...approved specimens for distribution is...well calculated to produce uniformity, system, and style throughout. ... Manly, steady, neat hand should be the chief aim. ... The copy-book might be prefaced by a few introductory remarks on the importance of...legible writing for records, especially for scientific purposes. ... 100 copies for the Department generally[2].

He did not think that the brush-drawing of hills was a suitable guide to the engraver or lithographer, in spite of its artistic effect ;

> Doubtless the power of expression which brushwork gives, aided...by...variations in colour and tints, ... enable the surveyor to produce a drawing...as far surpassing pen-and-ink as almost a painted picture does an engraving. But such pictures cannot be multiplied for publication except in pen-and-ink style. ... Unfortunately...transfer from the brushwork style to the engraved is left to the engraver, a person generally of city origin and training, who may never have seen a hill. ... I have known...very scrupulous surveyors who...made the transfer to pen-and-ink style themselves, rather than leave to it the engraver. ...
>
> Plans have to be published. ... If the field survey was done in black-and-white...*ab initio* ...the result could be put on stone or copper at once by the art of heliographic engraving[3].

He called for care in the selection of place names when reducing to small scale ;

> When the names...are too numerous...some must be omitted. ... Selecting those which are to be retained...can be better performed by a person intimately acquainted with the country than by a stranger. ...
>
> To render these general maps more useful to engineers, surveyors, and other professionals, every trigonometrical station should be given and its height recorded. The...heights furnished by our computations are referrible to the upper marks. ... The height of the ground would be more useful for...the configuration of the country[4] [68].

During the period of military activity following the mutiny, there was urgent call for maps to replace the old district maps ;

> Demand was daily increased by the influx of new regiments and new civil officers proceeding to reoccupy the stations which had been so completely destroyed. ... Instead of attempting to reproduce duplicates of the existing small maps of districts which are not always the most intelligible to the general traveller, it seemed...far preferable, both as regards time and general usefulness, to...bring a single map embracing the seat of war at one view on the reduced scale of 8 miles to the inch. For some time previously the compilations on this scale of Bengal and North-West Provinces had been in hand [312]. ...
>
> For the Lower Provinces...the object was so very emergent that it was necessary for the lithographer to insert only about one half of the names. ... Like all first works executed in great haste for special objects...considerable defects will creep in. The...map was meant

[1] DDn. 470 (105), DSG. to FD., 16–8–48. [2] DDn. 665 (166), 8–1–56. [3] ib. (293), SG. to DSG., 10–12–56. [4] DDn. 666 (1), from DSG., 13–7–58.

chiefly as a guide to troops going up the Trunk Road, and consequently it is...incomplete in many respects, although it served admirable purposes in time of great need [314–5, 483]. ...

The Hon'ble Court have strongly remarked on the crowding of the names of some of our Revenue Survey maps on the geographical scale from which all our compilations are made. The necessary omission of names to suit the scale—about one name in three for Bengal—must be arbitrary on the part of the draftsman.

Thuillier thought that the later revenue survey maps showing village boundaries made it easier to decide on the relative importance of village names [297] ;

The Revenue Survey of the N.W. Provinces was for the most parts a hasty and imperfect operation. The maps were never deposited...in the Surveyor General's office. In fact the survey was never generalized properly by the Surveyors, whose...originals were the barest skeletons, and...not forthcoming for many districts. ... Very serious and sad neglect took place as regards proper connection with the triangulation, and consequently we have always been in difficulties regarding the geography of that part of the country [IV, 218 ; V, 313]. ...

It is a remarkable fact that 20 years after the survey of the N.W. Provinces...no complete and accurate general map yet exists, and the difficulty I have had in putting the materials together has been immense [313–4][1].

Type-printing of names on the manuscript maps of Revenue Surveys was first introduced by Gastrell about 1860, and it was in that year that Thuillier drew attention to the great advantages of using stamps and dies for symbols and lettering ;

The published maps of the Ordnance Survey...are so universally admired...by both professional and non-professional persons, and are so inexpensive, that...this Department should without further loss of time have...constant reference. ... Many mechanical aids and contrivances are employed in producing...these maps, both as regards ornamentation, and the extraordinary uniformity of the writing. ... This is attained by means of punches...of metal made expressly for the purpose. ... Certain portions of the maps have only to be stamped with these punches or dies to obtain...the required effect of...different description of ground, trees, grass wastes, swamps, ... blocks of houses. ... The labour is thus reduced...whilst the result is...so... uniform and perfect as to leave nothing to wish for. In like manner the exact size of all capital and common letters are regulated by means of gauges. ...

I have...indented for a single set of these punches or dies. ... Should we find them answer I propose indenting for a sufficient number to meet the wants of the whole Department[2].

ORTHOGRAPHY

The transliteration and orthography of place-names is a matter of extreme interest to map-makers, and Markham devotes 15 pages to the subject [I : 248–50 ; III, 297 ; IV, 31–I][3]. Everest prescribed the system of William Jones for the Trigonometrical Survey whilst the Revenue Surveyors preferred that of John Gilchrist. Waugh not only maintained Everest's orders, but extended them to the Revenue Survey with some modification.

Use Italian vowels and no others. Expunge the letter U altogether ; adopt OO for the long sound as in *boot*, using A for the short sound as in BUT.

Express the harsh sound of C by K, and the soft sound by S, whereby C as an independent letter becomes expunged. Express the soft sound of J and G universally by J. ...

Dispense with the re-duplication of consonants as much as can be.

Drop superfluous letters...wherever they are so weak as to make it a matter of doubt whether they ought to be pronounced ; ... example, HYDRABAD. ...

It is as well not to interfere with...names...familiar by long use ; example CALCUTTA.

The sound F never to be expressed by PH[4].

Uniformity could not, however, be enforced throughout a vast country with such diverse languages and, writes the author of a volume of routes in 1853,

a fixed orthography of names, except such as are historically established, must be acknowledged to be unattainable. Gilchrist and others attempted to introduce a universal alphabet, and of course failed, not because the scheme is in itself altogether impossible, but because people will not take the trouble. ... The authority to whom we should be best disposed to bow is the Survey Department because, being actually present at each place noted in the survey, and

[1] DDn. 664 (233), DSG. to SG., 1–9–58. [2] DDn. 554 (38), DSG. to Mil. Dept., 20–6–60. [3] Markham (334–98). [4] DDn. 491 (89), 14–9–44 ; 478 (20), Sept. 1850.

coming in contact with its inhabitants, the Surveyors are most likely to be correct. But here we have unfortunately no such guarantee for accuracy, ... for except a Surveyor be also to some extent a philologist...his orthography will be just as fantastic as his neighbours[1].

General Walker thus reviews the subject in 1879 ;

Colonel Everest endeavoured to bring into general use Sir William Jones' method, which is at once elegant and phonical. ... That method gives to all vowels their Italian sounds, and as the difference between the English and Italian sounds are...very considerable, ... the surveyors...got into the way of using EE for the Italian I, and OO for the Italian U, and of spelling generally in the manner that is most natural to most Englishmen. ...

In 1871 the Government of India made arrangements for the introduction of a uniform system of spelling throughout India...prepared by Sir W. W. Hunter[2].

The Surveyor's difficulty has always been to reduce to English spelling the place-names of a tribal area where the inhabitants have no written language, and where their spoken words can hardly be rendered into either English or Italian sounds. The language expert may solve his difficulties by the use of strange diacritical marks which can seldom be used on the maps. The Surveyor in charge cannot deal personally with the thousands of place-names collected in one season—neither he nor his assistants can all be linguists—and it is not every district or political officer who is prepared to verify all the place-names collected.

CUSTODY AND DISTRIBUTION

Local officers suffered sadly from the general absence of printed maps [III, 274–5 ; V, 310–1]. The Surveyor General writes to the Magistrate of Mymensingh in 1844 ;

I am prohibited from furnishing any maps...without the express...sanction of the Government, communicated through the Secretaries at the head of Departments [III, 288–90].

With respect to...Mymensing, ... a map of that zillah was compiled...for the use of the Judge and Magistrate. The copies were...furnished on 6th June 1837, on a scale of 4 miles to an inch, compiled from Rennell's map and Captain Wilcox's survey [III, 16]. On the 10th July a map of the whole division of Dacca, Jalalpur, and Mymensing was furnished to the Commissioner, ... and again on the 18th July a map...for the use of the special Deputy Commissioner.

These maps, though very incomplete, contained all the information we have of those districts. ... There are no data for exhibiting the boundaries of thanas and pergunnahs. As the Revenue Survey progresses, the district will come to be regularly surveyed, and the important information which you require will become available[3].

In 1845, Wroughton protested against a request from the Deputy Governor that he should lend maps to the railway officers to be copied and returned. It was never forgotten that maps lent to Jervis under Government sanction had not been returned [IV, 308]. Standing orders were that no original maps

of which no transcript exists shall be sent out. ... When copies...are ordered by the Governor General in Council, or by the Governor General, such copies are to be made in the Surveyor General's office alone. ... Original...maps being once allowed to go out of the...office, their safety can be no longer secured. ... An original record...it is liable to loss or destruction. ... Material injury befell a very valuable map in passing between the...office and the Lithographic Press, and every enquiry failed to discover the party who had occasioned the mischief. ...

The railway establishment very recently effected a copy of maps...at the Surveyor General's office, an arrangement that could easily be followed by Mr. Simms and the engineer officers attached to him. ... Every reasonable convenience would be afforded[4].

In 1846 he had to report an apparently purposeless robbery,

chiefly of old fieldbooks, ... by...persons...who have had daily access to the office. Strong suspicion attached to a khalashee of the Mathl. Instrument Maker's Department. ... The matter is now under...judicial investigation. ... Our loss is...estimated at about 150 or 165 books. ... Several were transcripts ; of these the originals exist in England[5].

This was reported to London, watchmen were engaged, and an order issued for a monthly "muster" or check of all records. The Registrar reported that

[1] *Madras Routes* (pref.). [2] *GTS. Syn.* VII (pref., XII) ; JTW. Nov. 1879 ; Thuillier & Smyth, 1875 (appx., excii–vi, Simla, 10–11–71). [3] DDn. 453 (149–50) ; 20–5–44. [4] DDn. 370 (19), DSG. to SG., 7–10–45. [5] DDn. 471 (477). 9–7–46.

the chief bulk of the records, including maps, fieldbooks, etc., remains at your Presidency office. These are...under charge of the Deputy Surveyor General, but...Mr. Graham has...looked to the care and safe keeping of the whole of the documents, office furniture, instruments, etc., with the exception of the Reports and Computations of the G.T. Survey, which were...under Mr. De Penning's custody, and...since his death devolved to the care of the computers.

A large assortment of records, instruments, and...stores are with your field office, the charge...whereof have hitherto been entrusted to the Registrar. ... There are sundry reports, plans, and computations of the G.T. Survey...which are...under...the Chief Computer.

He recommended the appointment of a responsible officer and record-keepers for charge of maps and stores at the field office, and the preparation of a comprehensive register[1]. Closer control was enforced at Calcutta but, writes Thuillier,

when your establishment left Calcutta no receipts were given...for any of the books and records which were taken away. I am now having correct lists made. ... It is evident that no actual minute inspection of all the records has ever before taken place, and when the constant changes are taken into consideration, ... and the different removals from one house to another, it does not appear to be surprising that...papers should be missing.

The present state, however, ... is far from satisfactorily managed. ... In the absence of the Registrar and the higher salaried writers, the whole office should be under the surveillance of...Mr. Graham...in charge of the Drawing Office[2].

After the transfer of the map-printing section from the Government Lithographic Press in 1852 the stock and sale of printed maps steadily developed. Of each *pargana* map of the Lower Province revenue surveys 63 copies were struck off,

and distributed, largely to Railway and Geological Survey departments, and have been found particularly useful [IV, 209 ; 311]. Several other maps lithographed—North-West Provinces and Punjab—regularly advertised in the Government Gazette, and a steady demand maintained. 76 plans, 1,50,420 copies, some copied on transfer paper by...extra draftsmen, and paid for by contingent account, but all the printing executed by the fixed establishment. ...

The entire value of the work executed from...15th March 1852 to November 1853, a period of 20 months, ... would yield a very large profit indeed. Total number of copies printed, 3,37,112 maps—cost of drawing and printing rupees 19,817–8—establishment charges 16,850–10[3].

Supplies were now coming in of the ¼-inch district maps that had been printed in England, 270 copies each. During 1853–4, 1,759 of these were distributed to officials, and 593 sold to the public. Thuillier asked to be

relieved of the duty of selling maps to private applicants. By making over...all available maps to the booksellers of Calcutta they would be glad to undertake the task on the usual commission. ... In this manner the maps would also receive much wider advertisement than it is in my power to give them through the Government Gazette only[4] [306].

Sale on commission was approved, and the following year Thuillier reported that

all maps required by the public are...now disposed of by commission sale, whilst officials... are supplied as usual gratis from this office. A considerable reduction was at the same time made in the price of all our lithographed maps. ... I anticipate a larger revenue from this change. ... Rs. 2,338 realized by sale of maps to the public[5].

Whilst sheets of the Atlas of India were sold in England at 4 shillings each, sale price in India was fixed at Rs. 4 for the public and Rs. 2 for officials—Re. 1 in Madras. The current rate of exchange was two shillings to the rupee[6].

In 1855, Thuillier asked that the provisions of the Indian Copyright Act of 1847 should be extended to departmental maps [I : 256–8 ; V, 326] ;

Although every precaution has been taken with reference to the pirating of...reviews, magazines, and other periodical works, no provision...has been made...to protect the interests of Government with respect to...pirating of their maps and plans, ... which...are prepared at a very heavy expense to the State [183, 316]. ...

The map of a district...may not appear at first sight a costly production, but the expense... and time occupied...are...far beyond the value of most books. ... It seems but equitable that the Government should...[reserve] the right of printing and publishing the results of such a national work as the Survey of India. ...

A map of the Town of Calcutta & Environs which was prepared in this office...and lithographed under sanction of the Bengal Government [183]...[has] been reprinted facsimile, ...

[1] DDn. 465 (185–8), to SG., 4–4–48. [2] DDn. 472 (575–9), DSG. to SG., 15–7–48. [3] *GR Rev. LP., 1852–3* (54–5). [4] ib. 1853–4 (xlv), DSG., 1–3–55 ; cf. DDn. 661 (152), DSG., 5–10–55. [5] ib. 1854–5 (xvii). [6] DDn. 551 (56), CD. to B., 1–7–52 ; ib. 556 (151), 22–8–55 (111), CD. to B.

contrary to express prohibition, by...the Government printers, and issued by them in conjunction with their Almanac & Directory for the current year at a greatly reduced price. ...

I would...solicit that...steps may be taken for rectifying the defect in the Act[1].

Government had no wish "to remunerate itself for the expense of the surveys by the sale of its maps. ... If they can be prepared cheaper elsewhere than in your office, ... the public should have the benefit of the competition[2]".

From 1858 arrangements were made for a freer exchange of maps between India and England, and, writes the Surveyor General, in consequence of the interest now taken in Indian affairs, a much larger number of new maps should be sent to the India House. ... I would suggest...40 or 50 copies...for the Home Government and, in addition to those presentation copies...issuing in this country, ... 2 copies for the Topographical Depot of War under the...Ordnance Survey[3] [IV, 451], as well as 1 copy each to the Royal Geographical Society, the Athenæum Club[4], and to such military clubs as may appear appropriate[5].

Thuillier urged Government to encourage wide demand for maps ;

In consequence of...the...—extension of railways—the search for coal and iron—and other investigations, the necessity for good maps...is more urgent daily. The surveys of India have not yet been able to represent all the British districts and Native States, ... but very considerable portions...have been mapped. ... The results...should be...available for all purposes. ...

The Secretary of State...may...send out all the sheets of the Atlas of India, both for sale, and distribution to officials. ... These...are not to be obtained anywhere except in this office, and...I...act as map seller. ... The maps of the Ordnance Survey of Great Britain...are to be obtained in any number of shops...and, as maps in this country are still more urgently needed, ... equal facilities...ought to be given for obtaining them[6].

In his printed list of maps for sale, 1st January 1861, the Deputy Surveyor General includes the following amongst those available,

either at the Surveyor General's Office, or at Messrs. D'Rozario & Co.'s Library—Colored & unmounted—Colored & folded in book fashion—Colored on rollers [with price for each style].

Kumaun & British Gurhwal, compiled with the latest additions from the researches of Captain H. Strachey in 1846, and Lieutenant Richard Strachey, Engineers, in 1849–April 1850 ; scale 8 miles to or 1 inch Colored & unmounted Rs. 2 [187, 310].

The Kotah and Chukkata bhabur, or terae forest, of Zillah Kumaon, ... with the approaches to Nainee Tal and Almora, surveyed under...Lieutenants Vanrenen and Burgess...in 1851–1853, and compiled in the Revenue Surveyor General's Office on the scale of 2 miles = 1 inch. Colored and unmounted Rs. 2 [258–62].

Topographical Survey of a portion of the Delhi District, shewing the principal basins of drainage and the positions of the old bunds, also the situations of the ancient cities and the objects of archæological interest, in 16 sections, surveyed by Lieutenant F. Burgess...in 1849–50. Scale ½ mile to 1 inch. ... Colored and unmounted. Rs. 4 ; coloured on rollers, Rs. 7 [264–5].

Map of Rajpootana, embracing the Native States of Central India, from Delhi and Bhawulpoor to the Nerbudda and Taptee Rivers, and from the Sindh frontier and Gulf of Cambay to the meridians of Saugor and Jhansee. ... 8 miles = 1 inch, in 8...sections. 7½ feet by 6½ feet. Colored and folded Rs. 20 [315–6].

The Province of Pegu, compiled by Lieutenant E. C. S. Williams, Engineers and Officers of the Pegu Survey, from all available information. Scale 8 miles = 1 inch. Colored and unmounted Rs. 4 [196].

The list includes district maps of Bengal, N.W.P., and the Punjab, on 4-mile and 2-mile scales. "When district maps on scale 4 miles = 1 inch...are not available, the sheets of the Indian Atlas containing the required districts will be sent". The 2-mile maps showed village boundaries. "*Pergunnah*" maps on 1-inch scale were available for some districts. There were maps of cities and cantonments, and a list of sixty engraved Atlas sheets, for sale to the public at Rs. 4 each[7].

Copies and reductions sent as routine to the India House in London [III, 392–3] were sorted and listed during Markham's time at the Geographical Section in the *Catalogue of...the Map Room of the India Office*, published in 1878, to which reference is made in these Records. As might be expected many of those shown in this *Catalogue* are no longer to be found at the Commonwealth Relations Office. Some have been deliberately destroyed as being of small interest ; some of nautical interest were transferred to the Admiralty in London, whilst others were transferred to various authorities in India during 1924[8].

[1] DDn. 661 (159), DSG. to Home Dept., 3–10–55. [2] ib. (160), Rev. Dept. to DSG., 26–10–55. [3] amalgamated with OS. 1857 ; DDn. 646 (124), from DGOS., 8–12–57. [4] Waugh's own club. [5] DDn. 666 (1), to DSG., 13–7–58. [6] DDn. 554 (39), DSG. to Mil. Dept., 23–8–60. [7] *Map Lists*, 1858 ; 1861. [8] IO Records, letter to RHP., R 4206/62, 20–10–1962, re. *IO Cat.*

CHAPTER XX

MAP REPRODUCTION

Outside Agencies — DEPARTMENTAL: *Litho-printing — Photo-Lithography* — POSTAGE STAMPS.

A Government Lithographic Press had been started in Calcutta from 1823 under Dr. Nathaniel Rind [III, 298–9], and several private presses had been set up later, the most efficient for map reproduction being that of Jean-Baptiste Tassin [IV, 335, 469]. From 1840 a section of the Government Press under Arthur Sanders of the Q.M.G.'s department had been set aside to work for the Surveyor General [IV, 300, 313, 464].

When Wroughton took office as Deputy Surveyor General in charge of the Calcutta offices in 1844, he found that it was the regular routine to lithograph 63 copies each of all the revenue survey maps of Bihār and Bengal—village—*pargana*—district—13 copies of each being coloured by hand for immediate distribution [IV, 209 ; V, 305]. As a measure of economy he proposed

not to lithograph village maps at all, inasmuch as the boundaries and interior details...are delineated in the pergunnah maps, and in like manner only to lithograph those pergunnah maps which cannot be depicted in full...in...the district map. ... Also to color...only ten instead of 13 impressions. ... It is not...advisable to reduce the number of...impressions from 63, because after the first impression the expense is little beyond the cost of the paper.

A special section of draughtsmen was engaged for this hand-colouring[1].

In November 1845 he reported that the first four of the N.W.P. district maps that were now being compiled had been sent to press [IV, 289 ; V, 305–6] ;

I will not fail to forward for your examination...a copy of every map received from the... press, and as...transcripts...can never present the accuracy shewn by the original, I shall... send the latter with 2 lithographic copies to the Hon'ble Court [for the Atlas ; p. 306].

It unfortunately happens that the lithographic press is at present in a very inefficient state ; the establishment is very limited [327][2].

He sent a copy of the Etāwah map to the Lieutenant-Governor as a specimen of the whole series. "A moderate price would be fixed to ensure a demand from the public. ... As 300 copies only of each map will be struck off, ... early intimation of the wants of public officers should be given[3] ".

In June 1847 Thuillier, who had now taken over charge of the Surveyor General's office, deprecated the abolishment of the Government Press, describing the

Drawing Branch...as a most valuable and indispensable adjunct to the Survey Department. ... Without the aid...of a Press capable of producing and multiplying such records, the vast expense of a survey would be to a great extent negatived, and as there is no other Press in India at all capable of executing such...work, the abolition of the Government establishment would...be attended with very serious...detriment to the public service. ...

The Press...is quite inadequate to the demands I am obliged to make on it. The great delay now made in bringing out the maps which have been compiled in this office is not only extremely prejudicial to the public service, but equally so to the pecuniary interests of Government. ... The maps now ready for the Press and lying in this office cannot be lithographed under...about seven years, added to which the Bengal surveys now in rapid progress will provide such an overwhelming accumulation...that I have great hopes immediate measures will be taken to put the drawing branch on a more efficient footing.

During the past twelve months only 8 of the N.W.P. district maps had been lithographed[4], out of a total of 34 that had been compiled, besides 9 one-inch *pargana*

[1] BRC. 14–5–45 (21). [2] DDn. 471 (315–8), to SG. 4–11–45. [3] DDn. 470 (25–6), 16–1–46. [4] 70 copies each had been sold at Rs. 3 a copy after "advertising in all the daily newspapers for one month".

maps of Bihār. There lay ready for the press 19 district maps of the N.W.P. and 89 *pargana* maps of the Lower Provinces.

The perfection to which lithography is now brought in England makes me very anxious to...take advantage of it and send some of the Bengal district maps home for publication. ... I will undertake at my own risk and cost to try the experiment, and on the arrival of the lithographed copies, which I hope will be in a shorter time than the Government Press now takes to execute a single map, I shall...compare the cost with the Superintendent of the Press[1].

With Government approval two district maps were sent home to be lithographed by Wyld & Co. [IV, 294, 493][2], and 150 copies of each reached Calcutta eight months later. The prints were "executed in the most beautiful and clear style" which "almost bears a comparison with engraving", whilst the total charge for the two maps, including freight and insurance, came to £98-2-0, against the Calcutta estimate of Rs. 600, or £ 60.

as the price of simply lithographing the Mirzapore map without...the expense of printing and paper. ... The work done in England is considerably cheaper, while it is sure and certain in its results. ... Estimating the time that the simplest...maps take in going through the Government Press, I feel sure that so difficult a district as Mirzapore would not have been in the hands of the authorities for many years to come[3].

The Mirzapore map at Rs. 6 a copy, and that of Puree at 4 rupees, will pay the entire cost by the sale of 90 copies, for which we have subscribers' names recorded [311]. ... As the maps become more extensively known the demand for them is increased. ... By multiplying the number of copies the price may be reduced[4].

Later in the year five more district maps were sent to Wyld with request for 300 copies of each, 100 copies overland and the remainder by the Cape, "each district to be despatched as soon as ready"[5]. The Directors now ordered that future maps should be sent officially to India House, and the Surveyor General urged that there should be no risk of infringement of copyright ; "the immense expense of engraving the sheets of the Indian Atlas can never be repaid if the copyright is infringed" [I : 256-8 ; V, 323-4]. He shared Thuillier's anxiety to speed up the compilation and printing of the revenue surveys ;

The destructive ravages of climate and insects...render it peculiary desirable that such valuable and costly documents should be not exposed to the danger of being lost. ... The best mode of ensuring a satisfactory compilation under official...guarantee would be to despatch two manuscript copies to the India House by successive overland mails with an emergent indent for the number of copies required[6].

Manuscripts of five more district maps were sent to India House at the end of 1849[7]. From 1861, however, these district maps were printed at the Surveyor General's office at Calcutta as heavy arrears had accumulated in London. The *pargana* maps on the other hand went regularly to the Government Press, for it was impossible to send them also to London, and by 1851 their printing was much in arrears. It took from October 1845 to January 1848 to print off 35 sheets of Bihār District.

To counter the great shortage of lithographic draughtsmen Thuillier repeatedly urged that a section of the drawing staff and of the presses should be transferred to the Surveyor General's office under his charge ;

The Press being under the Quartermaster General's Department...I consider to be a great mistake ; I mean the Drawing Branch of it [IV, 313 ; V, 325]. If we had it here attached to your office ... I should be able to make a very different show. Wroughton said the same[8]

Twelve months later he reported progress on the district maps ;

Owing to the inefficiency of the Government Lithographic Press, the publication progressed at the rate of about 4 to 5 districts per annum only. This was brought prominently to the notice of Government, and...measures for the printing of the maps in England...sanctioned, by which...with a few exceptions the whole...of the N.W.P. districts have now been published, and...for the Bengal districts...no delay...need be anticipated. ...

[1] DDn. 472 (135-40), DSG. to Ben. Govt., 7-6-47. [2] Mirzāpur & Puri, despatched, 3-7-47. [3] DDn. 472 (401-5), DSG. to SG., 16-3-48. [4] DDn. 470 (92-4), DSG. to Govt., 8-6-48. [5] DDn. 459 (271-2), DSG. to Wyld, 29-11-48. [6] DDn. 473 (17-8), SG. to DSG., 14-7-47. [7] Bihār or Gaya, Shahābād, Sāran, Monghyr, & Midnapore. DDn. 462 (321-2), SG. to Mil. Dept., 13-6-49. [8] DDn. 472 (580), DSG. to SG., 17-5-48.

Six still remain in the Calcutta Press, and from the constant demand made for them unsuccessfully I can form no idea as to their probable time of publication. ... A want of paper is the cause assigned for their further detention. ... Until the Drawing Branch of the Lithographic Press is placed under the control of this Department...no satisfactory results can be expected. ... Trouble caused in correspondence with the Press is extreme, and the disappointments in the issue of a map...of more consequence. Not only the geographical maps of the North-West Provinces are thus in arrears, but the large-scale Bengal maps...are greatly behindhand[1].

Asked if he could take over full control of the Press, he replied that this would entail a correspondence with almost every public functionary in the country relating to...orders for the lithographing of forms...and returns of every imaginable description. ... The superintendence of such duties...is...totally incompatible with my present avocations. ...

The Drawing Branch...is a distinct matter, ... the correct copying on transfer paper of the maps of this Department. ... The Surveyor General and myself are the...interested parties in the conduct of this branch, ... and therefore desirous of seeing it put on an efficient footing. ...

While the survey records are increasing, and have increased fourfold, the outturn of the Press remains in the same inefficient state it has done for the last three or four years. ... Unless some immediate steps are taken, the heavy arrears now lying in this office, to the extent of eight years survey, never can be retrieved.

He urged the transfer of the drawing branch under the charge of Mr. H. M. Smith to the Surveyor General's office, and thought that "with...the proceeds from the sale of maps...I should in a very short time...turn this portion of the Press to a most advantageous account, and effect a considerable economy". He had arrears of 365 maps lying in his office awaiting printing—

300 pergunnah maps—20 district maps, large scale—31 district and general, geographical scale—14 index maps. ... At the average rate of progress made for several years past, ... such an amount of work could not be finished even in ten years[2].

DEPARTMENTAL LITHO-PRINTING

In July 1851 Thuillier put forward definite proposals for placing the map-printing of the Department on a good working footing ;

The remedial measures proposed are—1st. The increase of the drawing department.

2nd. The attachment to the office of an efficient lithographic press establishment. ...

3rd. Some plan with the Hon'ble Court of Directors by which maps compiled in this country may be sent to England and there speedily executed and returned.

The drawing branch of your Presidency office is manifestly inefficient. ... What we most require are good compilers, men of education and professional knowledge, who can be trained up to...put together discordant materials, and exercise sound judgement. ...

The want of an efficient lithographic press to work in combination with this office has long been...felt. ... It is only by a free and unchecked intercourse between the press and the drawing branch of this office (which does not now exist) that the public service can be carried on. ...

With reference to...some plan by which maps may be sent direct to...England and there speedily executed and returned, ... the system now in force...meets the case. These maps are beautifully lithographed by Mr. Walker, and returned without any unavoidable delay. ...

A local press is absolutely necessary, and...without one very serious impediments...would ensue. If every trifling requisition had to be sent home...the delay would...be prohibitory. At present many of the Revenue Survey maps on the larger scales are transferred to the stone and distributed to the...local authorities with considerable expedition, and this style of work is well done in Calcutta.

Mr. Wyld's bill for lithographing 11 district maps, ... including all charges for freight insurance, etc., average Rs. 712 each district, of 300 impressions. ...

I believe in a very short time, by judicious management, I could make the Drawing Branch of the Lithographic Press fully pay for itself. All that is now required is a small increase of establishment to start the business in an efficient manner, to work off the heavy...arrears, and keep pace with the impetus now given to survey operations all over the country[3].

Under Resolution of the 5th December 1851 the drawing branch of the Government Lithographic Press was transferred to the Surveyor General's office, with

[1] DDn. 480 (81–8), DSG. to SG., 25–5–49. [2] DDn. 562 (116), DSG. to Mil. Bd., 1–11–50. [3] ib. 112), DSG. to SG., 24–7–51.

additional establishment bringing the full cost to Rs. 720 a month, including Rs. 100 for the D.S.G. as Superintendent[1]. The establishment from the old press reported on 15th March, bringing two hand presses and equipment, which Thuillier considered quite insufficient for his needs, especially as the larger press was " a rough thing made by a bazar carpenter, requiring three times the amount of labour of a modern press". He asked leave " to procure two new iron presses...of the most approved construction. ... They may be had for 600 to 700 rupees each". ...

The number of lithographic stones received will be inadequate to keep the presses and the draftsmen at work. ... The order of Government is therefore requested to my procuring the stones, ... 6 Imperial and 6 Royal, and such others...as the...business may demand. Lithographic stones are sold by the weight, from about 5 to 6 annas a pound. One stone of...imperial size would cost at this rate about Rs. 60. ...

Nothing has been made over to me...to carry on even a single press...nor can such articles ...be spared. ... In order to save Government any further expenses...the proceeds derived from the sale of maps should be made available, the funds obtained in this way...now in my hands amounting to about 4,700 rupees. ...

The accommodation in the house occupied by the Surveyor General's office being totally inadequate for the addition of the Press, I have had it removed to very...convenient premises in the immediate vicinity. ... It is of the first importance that the two establishments should be as close together as possible. As time and opportunity permit I am anxious to make this establishment equal to every description of printing and engraving work, for the want of which Calcutta is so...behind every other place. ...

The appointment of a competent Head Assistant...is...of considerable importance. Mr. H. M. Smith, a draftsman in the Quarter Master General's Department who is an accomplished artist in lithographic drawing...has applied. ... I have informed Mr. Smith that I shall very pleased to nominate him provided he can obtain the consent of his immediate superiors[2].

All these proposals were approved except the appropriation of map sales ;

His Lordship is unable to sanction this proposal, and he desires that all savings accumulated now, and all that may be accumulated hereafter, from the sale of maps, be forwarded to the General Treasury...to the credit of Government. You should always apply...for permission to make any purchases...for the Press[3].

Smith's transfer was effected from 17th April. Three promising Indian draughtsmen were also engaged, and the Surveyor General agreed that the services of all the draughtsmen of the main drawing office should be available for litho-drawing when necessary. After a year's work Thuillier made proposals for increasing output ;

The small establishment[4] is becoming very efficient in so far as the present style of doing work by means of transfer paper is concerned. With a drag at starting of about ten years arrears, ... the establishment...has been sufficient to meet our most pressing wants, but it cannot be expected to work up to the steam power of the surveys now in force. Many of the old and valuable materials, ... therefore, embracing parts of the country entirely unknown, but eagerly sought after, must given way to the pressure caused by new surveys. ...

An intermediate man is required...to watch the press as the impressions are coming off, to guard against all imperfections and to ensure cleanliness and care on the part of the printers. An East Indian on...40 rupees would suffice. ... Provision should be made for the stone correcting, by the addition of...draftsmen on the ordinary salaries, say 25 to 30 rupees a month. ...

The method of...transfer paper is open to many disadvantages...caused chiefly by...influences of the atmosphere, which are so opposed to lithography that during the hot season the office hours are from 6 a.m. until noon, impressions not being pulled after 10 a.m., and the transfer drawings of large and elaborate maps become so affected as to spoil before they can possibly be finished by the draftsman. Hence large maps...are obliged to be cut off in small sections and put on the stone piecemeal. Every separate transfer endangers the appearance of...the expansion and contraction of paper which must be applied to the stone wet ; the chances of a perfect union of the sections is...extremely problematical. ...

The improvements...made in lithography in England and on the Continent consist of... *engraving on the stone*, ... performed so exquisitely as to give results almost as fine as copperplate engraving. ... The art of engraving on the stone is not yet known in Calcutta, and it would...be a step in the right direction if we could secure...a competent artist from England. ...

[1] DDn. 562 (219), Home Dept. [2] DDn. 564 (4), DSG. to Home Dept., 25-3-52. [3] DDn. 562 (221) Home Dept. to DSG., 12-4-52. [4] 1 Hd. Dmn. ; 1 Eur. dmn. ; 4 Indian dmn., 1 writer, with pressmen & 1 daftri.

Another improvement which I have long contemplated is the *tinted* lithography, or printing in colors [319]. The immense quantity of coloring work thrown on...the draftsmen in the two drawing branches...is...a heavy expense. ...

Two good new presses with the latest improvements (double side lever)...sanctioned by the Bengal Government...are not large enough for maps of the more important description, ... the preparation of which — cutting them into several sections and printing off on separate stones and sheets of paper, the rejoining of which is a most difficult job— ... detracting greatly from the appearance...of a map. ...

With good draftsmen and good presses it is essential to have good Paper, ... otherwise the labor is half lost, and the maps...are not sufficiently stout to bear handling. Nearly all the maps published have been...put on the most flimsy and wretched paper imaginable. ... Great endeavours have been made to obtain a better article. ... The Superintendent of the Press consented in October last to forward my indent containing a good specimen of lithographic paper...to the India House[1].

The Directors refused the services of a man from England to introduce engraving on stone, but arranged for supply of a larger press and "first-rate paper"[2].

In February 1854 Thuillier was called on to drop all map reproduction and devote the whole resources of his establishment to the printing of Postage Stamps, and the manner in which he succeeded in this colossal task is described separately [332–5]. During the stress of this special work the number of presses was increased, several new ones being made up in the Mathematical Instrument Maker's workshop under the skilled direction of Saiyad Mohsin Husain. Further addition was made by the purchase of presses and accessories that had arrived from England on the order of the Military Orphan Society which had since lost the Government contract for printing[3]. The staff was increased so that at the close of the emergency the Department was altogether in a very much stronger position. By September 1855 establishment had risen to Rs. 2,002 a month, and, writes Thuillier,

we have now...17 large and small presses, 10 of which are "iron-scraper" by Dean & Sons & Straker of London and Craig [greig] of Edinburgh. These vary in size...and are very fine machines containing the latest improvements. ... At the time I was called on to lithograph the postage stamps in February 1854 I had only 3 or 4 presses, and...I was obliged to make up several wooden presses in the Mathematical Instrument Department. ... In a very short time eight very excellent presses of the "scraper and double-side lever" principle were turned out, on which most of the Postage Stamps were printed. ...

The stones are all imported (German), and those fitting the largest presses are beautiful. ... In Calcutta only stones of a very small size are procurable ; these are likewise imported and sold at 4 to 5 annas per lb. The largest stones are sold in England at 2½ to 6d. per lb. We have no Indian stones in use, but I have seen specimens from the Asiatic Society of some rough pieces obtained from various parts of India [IV, 313, 466], but unless large slabs of an average thickness are procurable, they will come into but little practical use.

Good paper...for lithographic printing...is essential to produce good impressions. This we procure from England through the Stationery Department ; ... we are now well supplied with the proper article of all sizes.

The transfer paper is China, obtained...direct from Canton. ... Such paper is not procurable in the market here, but its soft texture and peculiar property is the best adapted for lithography. The solution of gamboge and isinglass is applied in this office.

The transfer, as well as printing, ink is made up on the premises. ... The best lamp-black is made from turpentine wick lamps, but this is expensive and only used for very fine work. The linseed oil for the varnish should be of the purest quality[4]. ...

A great desideratum...is a good supply of soft or rain water for setting the stones with the sponge during printing ; for the want of this I was unable to succeed with the red postage labels for some time. ... We now keep large Pegu stone jars with tin covers having lock and key to contain sufficient quantity for the whole of the hot weather.

The very hot months are...very hostile to lithography ; after 9 or 10 o'clock in the morning it is difficult to pull good impressions [328, 332–3]. ...

Lithographic drawing demands constant practice ; without this the hand fails in the delicate work and becomes unused to the preparation of the pens. ...

[1] DDn. 593 (391), DSG. to Home Dept., 6–7–53. [2] CD. to B., 22–3–54 (14) ; DSG. to SG., 30–6–54 ; DDn. 556 (36). [3] DDn. 563 (354), DSG. to Home Dept., 3–11–54 (481–2), reply, 17–11–54. [4] here quotes Schnefelder, 1819 ; Manuals by Hullmandel, London, 1832 ; Waterlow, 1834.

In addition to the Press attached to this office, the Chief Engineer has recently established one for...the Department of Public Works, ... whilst all the ordinary Form work...is executed at the old Government Press attached to the Stationery Department[1].

To the Surveyor General's request that the sheets of the Himālayan survey should be lithographed in colours [208, 318–9], he replied in June 1855 that

at present owing to the extraordinary and overpowering heat and denseness of the atmosphere it would be quite vain to attempt such delicate work. ... Such a task will require very full and careful superintendence. ... It will be essential to do it during the regular hours of business in the early morning. ... Each sheet will require four separate tracings and transfers to the stone.

The hill-shading must be done in light black and printed separately from the names ; ...neutral tint cannot be mastered. ... Delicate printing will be necessary, and I propose to make the lamp-black from turpentine wicks which will give far better results than mustard oil lamps [333][2].

The following year he reported that several of the draughtsmen were now able to draw direct on to the stone, getting much better results than by the transfer paper, but in 1857 he had to apologise for the poor results of two-colour printing on Lumsden's sketch map of the Kurram valley [pl. 2] ;

The attempt at expressing the ground in chalk on the stone and by separate printings has not been so successful as I...hoped for. ... As this is the first time we have executed such... work, allowances must be made. ... I look forward to being soon able to turn out a sketch map of this nature in considerably less time[3].

Two years later Waugh again pressed for the Himālaya sheets, and while regretting that no start had yet been made Thuillier replied that

the difficulty and labour is so great as to make me despair of ever being able to meet your expectation or your wishes. ... [He described] the very intricate nature of these plans, ... [and told of] the reluctance of our draftsmen to attempt the task which has been pronounced by Mr. Walker...to make even English engravers hesitate. ...

An attempt must be made to print the topographical details in separate colours ; without this I have no hope of the names being readable over the heavy mass of hill configuration. ... Printing in colours, however, is quite in its infancy in this office and, until we are supplied with the very purest materials...which are not to be found in Calcutta, and until we have better and more educated printers, ... I fear no great progress can be expected in an art which has not very long been fully developed even in England. ...

As soon as our first specimen is ready it shall be submitted for your inspection[4].

Work went better than expected and Thuillier reported two months later ;

The hills have been drawn on the stone in chalk and the other details by the usual transfer. The indexing, or registering, of the paper on four different stones is so difficult and uncertain owing to the unequal expansion of the paper on different days, and by different wettings, as to render it very improbable that we shall be able to succeed with the heavier sections. The present one had to be redrawn and retransferred several times. ...

The hill shading I think will answer well ; ... Mr. Musgrove will improve as he goes on. This is the first attempt only. The black writing contrasts well with the soft chalk shading, the results being produced from different stones and by separate printing. The drainage being blue relieves the hill-shading, and looks very well. ... We are very badly off for the red colour which is very hostile to clear printing, but I have sent to England for...colours of all kinds. ...

The lines of latitude and longitude and margin are in blue. This is necessary for preserving the true values and positions of the sites of places which we find must be of the same colour and printing as the streams to which they have such close proximity. We are now engaged in trying to effect better registration by means of tracing and drawing all details on the stone[5].

In January 1862 the complete set of 14 sheets, with an extra sheet for index and title, was issued in atlas form [208, 319 ; pls, 6, 10][6]. Montgomerie was the first to send his congratulation ; " I am delighted to hear that you have finished the degree sheets. What a triumph over the Geographer [John Walker] and the Indian sea. Your Atlas will be well worthy of a place in the Exhibition "[7]. Thuillier was proud to report

These...elaborate maps, on the scale of four miles to the inch, delineating this most difficult ...mountainous country, were executed in the style of chromo-lithography, each plate having

[1] DDn. 564 (249), DSG. to CE. Madras, 29–9–55. [2] DDn. 661 (52), DSG. to SG., 5–6–55. [3] DDn. 669 (16), DSG. to SG., 1–4–57. [4] DDn. 668 (116), DSG. to SG., 17–6–59. [5] DDn. 668 (161), DSG. to SG., 9–8–59. [6] *IO Cat.* (239) ; MRIO., 6 (28–41). [7] DDn. 25 (167), 21–9–61.

four printings, and by a combination of chalk drawing for the hills direct on the stone, with transfer drawing for the outline, writing, and figures, a very successful result was produced. ...

A copy of the same atlas sent to the Great Exhibition of England [1862]...has...obtained for the Department the honour of a prize medal, a further incentive towards effecting still greater improvements in the beautiful art of printing from the stone [pl. 10][1].

Three sets of the atlas were despatched to England in May 1862, one copy for the Council of India, one for Sir George Everest, and another for Sir Andrew Waugh under whose direction both survey and publication had been effected [319].

Thuillier was even better pleased with the map covering Johnstone's survey of the Derajat [219]; "The preparation of this map has been tedions job, ... lithographed and issued in a style which has never before been arrived at in India"[2].

PHOTO-LITHOGRAPHY

In 1856 the Surveyor General applied without success for the services of William Glynn [IV, 384; V, 419], a keen amateur photographer, to assist in experiments at Dehra Dūn " with the view of ascertaining whether the art of photography...can be applied to...multiplying copies of manuscript maps."[3].

In 1857 two plans were sent out from the Ordnance Survey at Southampton as specimens of the use of photography in reducing maps from one scale to another. These were lost in transit during the disturbances of 1857 and, when asking for replacements the Surveyor General asked for two "complete sets of 1st class photographic apparatus suitable to the purpose of multiplying plans by photography [141]". These two sets were purchased by the Ordnance Survey and reached Calcutta in January 1860 but, writes Thuillier in May 1861,

with my present inadequate staff and manifold avocations I am totally unable to devote sufficient time or attention to this fascinating study. ... Without a practical photographer of acknowledged experience on this particular...work attached to my establishment, I fear our amateur experiments would only lead to expense and loss of valuable time[4].

Meanwhile Government had approved the local purchase of a camera and photographic apparatus for the Kashmir survey where Melville made good use of them though not on actual map reproduction [141, 235].

Whilst on furlough during 1859, Depree visited Southampton, and reported on the process of photo-zincography. Town plans of scale 1 : 500 were reduced to scale 1 : 2500 to make parish plans, which were then further reduced to make 6-inch county plans. The Surveyor General agreed, however, with the Director General of Ordnance Survey that the system would be of little use in India for the reduction of one-inch topographical maps to the quarter-inch scale; "maps would have to be specially drawn for such reduction"[5].

From 1st June 1862, however, a small photo-branch was started at Calcutta under two Sapper n.c.o.'s sent out from Southampton[6], whilst at Dehra Dūn where the Kashmir party was in recess, the photographic apparatus was "employed in furnishing preliminary copies for current use until the originals are engraved and published". "But the results, though exceedingly useful, fall short of what is produced by photo-zincography or photo-lithography"[7].

Whilst on furlough in England in 1864–5, Hennessey spent several months at Southampton where he mastered the art of photo-zincography. On his return to Dehra in March 1865, he superintended the erection of a press, and from that time onwards trained a succession of officers in the work. Of these James Waterhouse, of the Artillery, joined at Calcutta in July 1866, and held charge off and on till 1895, from 3rd March 1867[8].

[1] *GR Topo 1859–62* (19); DDn. 21 (72–5), SG. to Mil. Dept., 22–5–61; ib. 6 (156), SG. to STS., 3–10–61. [2] *GR Rev.* 1857–61 (16); from SG., 12–9–62. [3] DDn. 645 (201), SG. to NWP. March 1856. [4] DDn. 21 (77–8), SG. to Mil. Dept., 22–5–61. [5] DDn. 664 (359), James to SG., 18–12–58; DDn. 4 (57–62), SG. to Depree, 22–3–60. [6] James McKenzie, still serving 1880, & Wm. Crossley; DDn. 97, *Roorkee Papers*, I (471). [7] *GR Topo., 1862–3* (6); *GR Trig., 1862–3 & 1863–4* (13). [8] *GR Topo., 1865–6* (31); *GR Trig., 1865–6* (24–6), Markham (176–7).

POSTAGE STAMPS

During 1853, under instructions from the Court of Directors, the Government of India called on the Calcutta Mint to produce designs for a series of postage stamps; their requirements could not be met by printers in England for two or three years. The Mint designed a two-anna stamp with lion and palm-tree, and printed about a million of them in green, but these were never issued. They also designed a red half-anna stamp, but had no facilities for printing and in January 1854 Government asked the Deputy Surveyor General if stamps could be printed on the presses that were now installed at the Surveyor General's office. On 22nd February Thuillier submitted proposals for taking up the work, together with designs with the Queen's head prepared by his head draughtsman, Mariano Smith[1] [357, 360],

The accompanying four specimens...have been drawn on transfer paper and struck off in a hurried manner. If these designs are approved, I propose to get them carefully engraved on the stone and then multiplied by transfer so as to cover a moderate size stone containing ...144 stamps, which being pulled in a Royal size press, 300 sheets may be obtained in one day, and on an average one million per mensem, provided always that the drawings on the stone do not become thick and bad. ...

I have...estimated...for an increase of only 6 presses with a complement of working men, and two presses spare...for transfer purposes. ... The entire establishment...will...produce 30 millions of stamps at a cost of about 200 rupees a million, not inclusive of paper. The paper, of which specimens have been furnished from Serampore with a watermark on it is of too rough a texture. If a finer...paper can be supplied it will answer...against counterfeit. ...

The stamps in single colour are the most easily produced...[and] more businesslike. The double colours will require immense time and care. ...

In the Superintendent of the Press, Mr. H. M. Smith the Government possess a most excellent ...public servant to whom is due all the credit of the designs[2].

Government approved the increase of establishment and purchase of extra equipment [329]. At the Stationery Office, a suitable paper was received from England, on which the stamps for deed and promissory notes are struck off. This...is well fitted for lithographic purposes, and being...covered with a good and distinct watermark will...serve for the postage stamps until a more suitable article is expressly made[3].

The first point of importance, wrote Thuillier, was a representation of Her Majesty's head. After repeated trials, ... a bust drawn on transfer paper and afterwards engraved upon the stone, with the words "India" at the top...and "Half Anna" at the bottom, was adopted. ... A sufficient number were laid off upon the stone so as to preserve uniformity and to form a convenient block of one hundred and twenty, three of such blocks filling the sheet of stamp paper. ...

A...number of stones were prepared and, after many disappointments and unceasing labour, ... were charged with the red vermillion English lithographic ink[4], a very small quantity of which I happened to have by me, and a few hundred sheets were struck off and transmitted to Bombay by the steamer of the 5th instant.

On the...English...vermillion ink being expended, colour of apparently similar quality was obtained from the Stamp Office, but this was found entirely to destroy the impressions on the stone, the proofs coming off thick and smeared...so as to render the stamps unserviceable.

Prompt orders were despatched to Bombay to suspend sale, but a few reached the public. Thuillier made another trial;

All the stones...were cleaned off, and the whole of the materials...were made up fresh from the purest ingredients obtained from the...dispensary, and in our own presence, doubts having arisen as the to purity of the transfer ink...previously used. ... To secure a good standard, ... a careful engraving on copper has been made[5], ... and from this plate transfers have been obtained which are undoubtedly superior to the former lithographic standard.

With these precautions...the blocks were again formed on the stones, ... but in smaller blocks of...96 each, ... more conveniently saleable in equal rupees, and from the sharpness of the transfers from the copper plate I fully hoped that success would attend. ... Printing...has been tried both early in the morning and late at night, and no pains have been spared to guard against the defects which have hitherto prevented them from being struck off.

The results were bitterly disappointing;

[1] value ½, 1, 4, and 8-anna. [2] DDn. 564 (87), DSG. to Home Dept., 22-2-54. [3] ib. (91), from DSG., 8-3-54. [4] sulphide of mercury. [5] by engraver Namiruddin.

It is evident that lithography in this country, and during the hot season especially, cannot be relied upon, and...steps should be taken to procure proper stamps from England.

Attempts were then made to print in blue; cobalt was no better than vermillion, but refined indigo was more promising, whilst black was better still;

The impression in black is distinct and fine. The printing ink—composed of simple lamp-black obtained from the best turpentine wick lamps—...works so well with our maps that we should find no difficulty in proceeding at once with the stamps in this style. ... The large sheets...do not print so well as the small ones. ...

I...recommend that the half-anna stamps be proceeded with at once in simple black printing, and in single blocks. ... The blue colour, if successful, can be reserved for the one-anna stamp, and to ensure a due contrast...for night work at the post offices, a different shape stamp can easily be adopted[1].

Further experiments with indigo were, however, successful, and on the 5th May Thuillier reported in person to the Governor General that good progress was being made with the half-anna stamps in blue, of which "during...yesterday alone, the first day of real progress, by keeping the presses at work double hours", nearly a lac and a half of stamps had been printed off. Arrangements were now made for officials of the Stamp Office to take the stamps over from the press about once a week. On the 11th Thuillier reported that

the printing of the half-anna stamps in blue has progressed very satisfactorily indeed. Up to the present date one million and a quarter...have been struck off and, by employing our establishment and presses from 6 a.m., until 8 p.m.—two hours intervening for refreshment—I am now able to obtain about 3 lacs per diem. This number will be increased when additional presses can be procured, and for which due arrangements have been made for getting the manufacture in Calcutta as speedily as possible. ...

I respectfully solicit permission to remunerate the printers and pressmen by payment for the number of extra hours they are actually employed daily, which is equal to a full day's ordinary work. ... The establishment has shewn the utmost activity and good will.

The Survey had to make all security arrangements because the Stamp Office officials declined to keep the long working hours;

I have been supplied with the watermarked paper in the original boxes as received from England, containing 15 reams. ... If we return an equal quantity of paper stamped with postage labels every object is attained. It will not be practicable to lock up the lithographic stones in chests; they cannot easily be removed from the presses. ...

The press room is guarded by a jemadar and four burkundauzes day and night, whilst the room where the paper is kept is locked up on all sides. Every person...is searched on going out, and from...my own constant attendance...I believe every possible protection is afforded for the safety of the stamps[2].

On the 26th June Thuillier reported that

up to the present date 13½ millions of the half-anna labels have been struck off and delivered to the Stamp Office. I had hoped to have greatly exceeded this number, but owing to the Ramazan fast of the Mahommedans, which commenced on the 27th of May and has been strictly observed by the greatest proportion of my pressmen and printers, it has been found impossible for the men to work double hours. This restriction will...be removed in two days, when we shall proceed with renewed vigor and extended means[3].

The last of the four wooden presses—imperial size—double side lever action—ordered from the workshop in March was delivered on 20th June. They were "so good and well adapted...not only for the postage stamps, but for the general mapping business" that Thuillier ordered four more of the same pattern[4].

The stamps were scrutinized in the Stamp Office and 20,000 blocks were rejected from those delivered on 14th July, some of them "spoilt...owing to the imperfect cutting of the paper into separate sheets". Thuillier commented that

the whole of these sheets have been carefully examined, and gone through several hands in this office. All those which were...passable have again passed through my own hands and, although a great many may be...saleable, ... I am anxious to allow none to be distributed that are not really good, and I have therefore condemned the whole with the exception of 58 sheets which appear perfectly fit for use. ... The remaining 15,000...I am quite content to accept your opinion of them. ... These rejections...amount to scarcely two of our best day's work.

[1] DDn. 563 (209), from DSG., 28–4–54. [2] DDn. 564 (107), DSG. to Rev. Bd., 19–5–54. [3] ib. (116), DSG. to Home Dept. [4] ib. (123), 10–7–54.

By 31st July the last batch of the 30 million half-anna blue were handed over, and a start made on the one-anna ;

A fair contrast with the half-anna label being essential, I determined on again persevering with the red colour. ... By means of our improved materials and the constant experiments, ... the...one-anna labels are now printing...steadily...and, although more time and care are required in the manipulation, ... I trust an ample supply will be speedily obtained. ...

The number required, ... not more than 5 millions, will be ready within the present month. Of the half-anna, I am informed that when 35 millions have been completed no more will be required. On the present date, 11th August, we have...

Half-anna,	blue,	31,743,360 labels,	value Rs. 991,980.
One-anna,	red,	2,562,112 ,,	,, Rs. 161,382.

A considerable number have been rejected on account of imperfections in printing, damaged paper, and bad cutting of the treble-block sheets into single blocks. This was to be expected when we take into consideration the extreme haste with which the work has been executed—a considerable portion having been done by candle-light...—very...inexperienced men we have been obliged to entertain and instruct—and the new machines. ...

A flaw in a single label invalidating the whole block, about 20,000 blocks have thus been rejected. ... Somewhat relieved by the quantity in store, more time can now be devoted, and... better printing secured. The cutting of the sheets I have also provided for in this office, as their appearance suffered by...tearing them in the Stamp Department.

Start was now made with the four-anna stamps in red and blue ;

A standard...has been engraved and several experiments made in printing in two colours, ... These labels have all been protected by the watermark, and only one dozen placed on each sheet, with the double object of facilitating the postal accounts and rendering the printing easier. ... The difficulties, however, of the double printing are so great that I fear it will not be practicable to produce the four-anna stamp in this style in sufficient quantities. The registering...of the paper on the stones demands the uninterrupted presence of a European assistant of experience. ... Many sheets will have to be rejected. ...

The eight-anna label has not yet been commenced...because the Director General...hoped the 4-anna one would supercede the necessity of a higher label. ... A two-anna label has lately been suggested and a standard is now engraving for it[1].

After yet another hitch over the supply of vermillion, and the usual interruption by the Pujah holidays, printing was brought to a close, and delivery of the last consignment made on 28th October, bringing the total to

Half-Anna,	blue,	31,958,	784,	value Rs. 988,712
One-Anna,	red,	7,858,	368,	,, Rs. 491,148
Four-Anna,	red and blue,	206,	040,	,, Rs. 51,510.

The standard copper plates [writes Thuillier] have been carefully placed under lock and key under my own seal and that of the Supervisor of Stamps, and the blocks on the stones have all been cleaned off. I shall be prepared to strike off additional quantities...whenever it is the pleasure of Government. ... Every sheet of...watermarked paper has been duly...accounted for. ... The current duties of the press in the mapping department will now be resumed[2].

During December and the following March, two more batches of the four-anna stamps were struck off, to the number of over one million labels or stamps. For the second printing they were set 24 to a block instead of 12, to economise in the watermarked paper and in printing time[3].

In July 1855 a further one month's supply of the half and one-anna stamps were called for and printing continued as demand required until news came that the supply of stamps from England had reached Bombay in October[4]. Four-anna stamps were completed with the second colour and the last were delivered to the Stamp Department on 3rd November. The final total of stamps numbered 47,732,596, to the value of Rupees 21 lacs, 180,668[5].

In recognition of his part in carrying out this formidable task—altogether beyond his duties as Deputy Surveyor General, Superintendent of Revenue Surveys and Mathematical Instrument Department—Thuillier was granted a special allowance of Rs. 350 a month, which he drew from February 1854 to November 1855. He records that

[1] DDn. 564 (137), DSG. to Home Dept., 11–8–54. [2] DDn. 563 (340), DSG. to Home Dept., 2–11–54. [3] DDn. 564 (188), 13–12–54 ; (225) 26–5–55. [4] printed by De La Rue & Co. of London. [5] DDn. 564 (259), DSG. to Supt. Stamps, 29–11–55.

the device for the stamps and the success in printing them in colours were entirely due to Mr. Smith's unwearied labours. ... Disappointment attended our first endeavours, but by perseverance of no ordinary character the difficulties were at last surmounted, and the demands... for...thirty millions of heads were actually complied with under the time estimated, and sufficiently early to permit of the introduction of the new Postage Act on the date intended. This could only be effected by prosecuting the duty double hours which involved...superintendence from 6 a.m. until nearly 9 p.m. daily. In consideration of this duty Rs. 100 was added to Mr. Smith's salary, which no servant of the Government ever more richly deserved[1].

Several of the stones and plates on which the various experimental and working designs had been laid down were preserved at the Surveyor General's office, and at various times, 1890, 1894, and 1915, coloured prints on common paper have been taken, some being printed within a border bearing the note "Facsimile copy, 1894", others with the printed word SPECIMEN spaced on the reverse.

In 1916 and 1922 these 9 stones and 6 steel and copper plates were officially presented to the Royal Philatelic Society in London, together with 10 sheets of specimen stamps [pl. 20][2]. These plates had been engraved by "Numeruddin" from designs by Mariano Smith [332].

Copies of letters from D.S.G.'s correspondence book of 1852–5, and of a few specimen stamps have been lodged in the Survey Library at Dehra Dūn [special shelf, Q 52]. Other accounts will be found ;

Report by Mr. Douglas Garth before the Royal Philatelic Society, 9th January 1891.

Report read on 6th March 1891, by Mr. T. K. Tapling after a visit to Calcutta during 1889.

Report on Postage Stamps of British India & Ceylon covering these two papers, pub. by the Philatelic Society, London, 1892.

Bengal Past & Present. XI, 1915 (234 . *The Calcutta Printed Postage Stamps of 1854–5.* Wilmot Corfield, Curator, Royal Philatelic Society.

Statesman, 12th Jan. 1954, letter from Ramesh K. Ghoshal, 10–1–1954.

The Indian Archives. VIII/2, July–Dec., 1954. *The Indian Postage Stamps of 1854–5.* R. H. Phillimore.

[1] DDn. 624 (83), DSG. to SG., 5–4–56. [2] SG. to R & A. Dept., 7–1–1916 ; RPS. to R & A. Dept., 19/20–4–1916 ; Royal Philatelic Soc. to SG., 13–10–1922.

CHAPTER XXI

ADMINISTRATION : THE SURVEYOR GENERAL

Surveyor General & Superintendent Trigonometrical Surveys — Field Office — Clerks — Draughtsmen — Computers — Correspondence & Reports — Finance.

WHEN he took over charge of the Department on 16th December 1843, Andrew Waugh had served eight years with the trigonometrical survey under Everest, and had acquired thorough knowledge of its principles and practices, and of all Everest's plans for the future. He had won Everest's complete confidence, and during the eighteen years that he held charge of the double post of Surveyor General and Superintendent of the Great Trigonometrical Survey, he proved an administrator and organizer of outstanding talent, under whose direction the trigonometrical survey was extended widely on the soundest geodetic principles, whilst topographical surveys and mapping, in which he had no previous apprenticeship, were developed to an extent hardly thought of by Everest. Revenue surveys were extended in all three presidencies but, as in Everest's time, did not call for the Surveyor General's personal direction.

Waugh started without a deputy, for the post of Deputy Surveyor General and Superintendent of Revenue Surveys had been vacated by Bedford in January 1843, and was not filled until Wroughton returned from furlough in March 1844. He at once took over control of the revenue surveys of the Bengal Presidency under the Board of Revenue at Fort William, and on Waugh's departure up country assumed charge of the Surveyor General's offices at Calcutta [348]. Waugh left Calcutta in October 1844, to make his headquarters at Allahābād for the better control of his trigonometrical parties [122]. Dehra Dūn and Mussoorie were temporarily abandoned.

> Allahabad and Benares are the two stations specified in the Hon'ble Court's despatch as the most appropriate localities for my headquarters in the field [IV, 319]. Allahabad may be considered the more eligible. ... Its proximity to the Karara meridian should not be lost sight of ; ... operations in that quarter...have hitherto proceeded at a very slow rate [11][1].

His journey by boat up the Ganges, accompanied by a select staff of clerks, computers, and draughtsmen, took nearly seven weeks [IV, 170].

Unlike Everest Waugh took no regular share in field operations, but kept himself free to tour round his field parties inspecting and advising his many new officers. Renny had taken furlough and James had died ; Shortrede failed again. Young military officers were brought in, and some of the more experienced of the civil assistants succeeded to executive charges. Arrangements had to be made for shifting the parties from one meridian to another, and to the new longitudinal series that was to run from Rohilkhand to Purnea through the *tarai* forest along the foot of the Himālaya.

Towards the end of 1846, he found it convenient to shift headquarters from Allāhābād to a more central situation at Digha Ghāt between Dinapore and Patna [13 ; pls. 1, 3]. Time had come to measure a new base-line at the foot of the hills north-east of Purnea, which called for the presence of the Surveyor General himself and two of his field parties. Whilst his office moved to Digha, he himself marched eastward to inspect the site at Sonakhoda which Walker had selected. He planned to spend the rains of 1847 at Darjeeling, and on Walker's untimely death he himself

[1] DDn. 452 (170-2), SG. to Mil. Dept., 20-8-44.

INDIAN POSTAGE STAMPS

Surveyor General's Office, Calcutta, 1854–5

[Ch. XXIII]



The envelope is a reproduction of one posted to Alexander Wyatt at Mymensingh in February 1856 [Ch. XIX].

The top row shows stamps printed in indigo and vermilion, and officially issued. Reproduced from specimens struck from original copper-plate dies without exact matching of colours.

The two lower rows show experimental designs reproduced from specimens struck from copper-plates and lithographic stones.

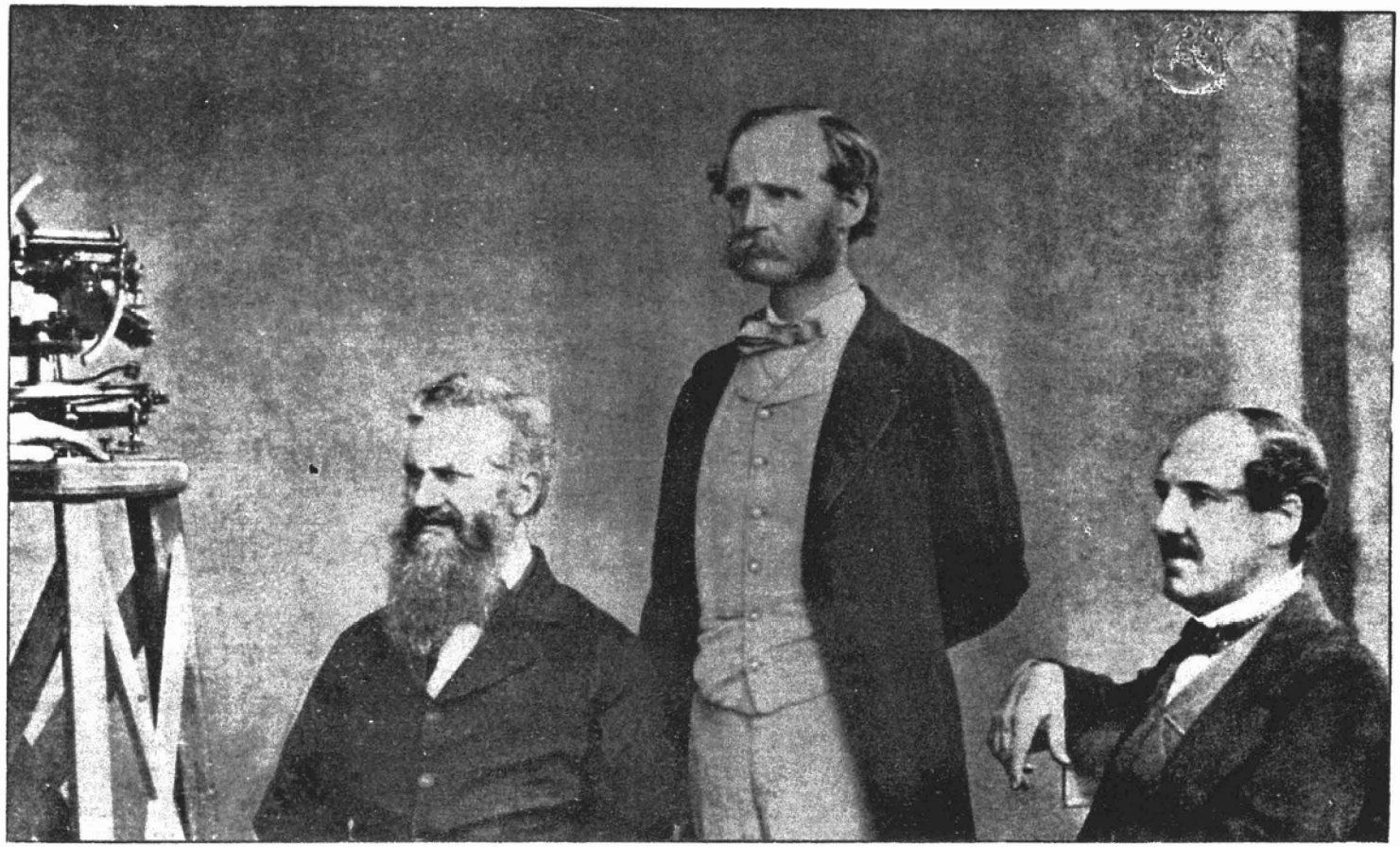
Reg. No. 6080 HD'55-800'56.

Printed at the Survey of India Offices (H. L. O.)

ANDREW SCOTT WAUGH
(1810–78) F.R.S.
Bengal Engineers
Surveyor General & S.T.S.
1843–61

JAMES THOMAS WALKER
(1826–96) F.R.S.
Bombay Engineers
S.T.S. 1861–84
Surveyor General 1878–84

HENRY LANDOR THUILLIER
(1813–1906) F.R.S.
Bengal Artillery
Deputy S.G. 1847–61
Surveyor General 1861–77



A. S. Waugh Lt Col.
Surveyor General of India

J. T. Walker.

Henry Thuillier
Revenue Surveyor

This group was photograpned at Calcutta in March 1861, at the time of Sir Andrew Waugh's retirement. It included Montgomerie, who was standing to the left of the theodolite [pl. 23]

took over the special triangulation in the Sikkim Hills from which to fix the positions and heights of Kangchenjunga and surrounding peaks. This occupied him till it was time in November to start measurement of the base [19–20].

Following the Sikh War of 1846 and the British occupation of the Punjab the Surveyor General was called on to extend triangulation to the west [34]. No party would be available before October 1847 and Waugh himself was engaged

in supervising the Bengal parties and in making preparations for the measurement of a base of verification for these provinces. This important...undertaking I hope...to finish by 15th Feb. 1848, after which I shall be free to proceed myself to the North-West. ... There is no man in India at this time to whom I could delegate the task of superintending the base. ... Captain Renny...has not yet returned from England, and he is the only officer excepting myself who has been instructed in this particular branch of a geodesist's duties. ...

After the measurement is completed the work...in Bengal will...not require my presence[1].

On completion of the base-line measurement, therefore, Waugh marched west to Dehra Dūn, his route being planned to run—

Purnea, 29th January 1848—Bhagulpore, 8th February—Monghyr, 11th—Dinapore, 21st—Ghazeepore, 4th March—Benares, 9th—Allahabad, 18th—Cawnpore, 29th—Allygarh, 16th April—Meerut, 25th—Dehra Dun, 3rd May[2].

From now till his retirement he made his headquarters at Dehra Dūn and Mussoorie. He bought Lauriston as his residence in Mussoorie, and maintained a small office and observatory there during the rains [138]. He devoted much of his attention to the north-west and to the Himālaya mountains, taking particular interest in the heights of the snow peaks, and in the problems of refraction and Himālayan attraction [63–6, 90–7, 133–7]. In October 1849 he proceeded to

Peshawar to examine the ground in advance of the North-West Himalaya series, and select a proper situation for the proposed line of verification which will be measured either in the plain of Chuch or the valley of Peshawar. ... I started from Captain Du Vernet's stations in the Jalundar Doab...and carried a route survey...with peculiar care via Amritsar, Lahore, Wazeerabad, Jhelum, Rawal Pindee, Attock to Peshawar, taking astronomical observations...at each of these places [36, 317]. At Lahore I was ordered by the...Governor General to examine the Indus at Attock and select a position for a permanent bridge. I accordingly made a survey of the river, with sections, and submitted a report on the subject [43].

It was my intention to have returned from Peshawar via Kohat, Kalabagh, and Mooltan, ...but, having received a report from Captain Du Vernet that his instrument was out of order, I was obliged to hurry back to join him. ... I met Captain Du Vernet at Pogansir and occupied myself in examining his work and placing his instrument in order [35][3].

During season 1850–1, Waugh travelled through Oudh and inspected Armstrong's party on the Hurilaong series running through west Bihār, and at the end of 1851 he made a second visit to Peshāwar to meet James Walker and Robinson who had been recently placed under his orders for topographical surveys [210, 215].

The demand for maps was increasing in all directions, and the extension of trigonometrical survey now rendered topographical surveys a practical proposition. For the north-western and lower provinces of Bengal the district revenue surveys were used and Waugh insisted from the first that adequate points should be provided for their incorporation into the quarter-inch Atlas [295, 312].

At the end of 1852 he set out east to see the start of the Assam longitudinal series, and met Du Vernet near Jalpaiguri where he was struggling with appalling conditions of water-logged plains teeming with malaria. Leaving Dehra Dūn by *dāk* [IV, 170] on 12th December, he passed through Allahābād on 19th, and Bhāgalpur on 14th January, " a tedious march of nearly 2,000 miles".

I dispatched my field office in advance in light marching order under charge of Mr. Duhan, ... intending to join it myself in north-east Bengal. ... I instructed Mr. Duhan to make forced marches when practicable by doubling the usual stages, and dividing three stages into two. The camp...was an exceedingly small and compact one, consisting of not more than 60 persons including establishment, guard, and camp followers[4].

[1] DDn. 462 (90–6), SG. to Mil. Sec. 12–12–46. [2] DDn. 589 (1), SG. to Chamarett, 18–1–48. [3] DDn. 542 (1), 25–1–50; Report on bridge site. ib. (37), & 549 (9), SG. to Mil. Dept., 28–8–50. [4] DDn. 547 (6), SG. to NWP. Govt., 14–1–53.

He reached Titālya on 24th and Jalpaiguri on 26th January, and met Du Vernet at Mudarganj on 27th. He urged the provision of elephant transport and other assistance ; "the importance of the series is so great that I...feel the greatest anxiety for its prosperous progress [29]". On his return journey he reached Purnea on 7th February and Bhāgalpur on the 17th. From there he took steamer down to Calcutta ; "the machinery of the *General Macleod* having sustained some injury ...her progress will not be so rapid as might otherwise be expected"[1]. This was his first visit to Calcutta since 1844 and nearly nine years since he had seen

the Deputy Surveyor General and my office at the Presidency with its several adjuncts ; viz., the Drawing Department—Lithographic Press—Mathematical Instrument Workshop and Department—Computing Office and Observatory[2].'

He was back in Dehra Dūn on 5th April.

He devoted season 1853–4 to the measurement of the Chach base-line [42–3], taking the opportunity to inspect all his Punjab parties, and at the end of 1854 he went down to Karāchi, travelling by river from Ferozepore and being held up at Mithankot by one of his rare bouts of fever [43–4]. During the measurement of the Karāchi base-line he reported to Government that

after completing all my arrangements...in Sind, as well as inspecting the Bombay trigonometrical survey party under Lieut. Nasmyth, I propose...to proceed by sea, via Bombay and Madras to visit my office at Calcutta. ... I propose to limit the office establishment accompanying me on this part of my tour to my officiating Registrar, Mr. Duhan[3].

By this constant touring Waugh kept close touch with all his field units excepting the East Coast series and the Orissa and Hyderābād topographical parties which caused him considerable anxiety. To increase control by meticulous professional directions he compiled his *Instructions on Trigonometrical Operations* [98] and *for Topographical Surveying* [282][4]. He called for a high standard of topographical work from the new parties in the Punjab and Himālaya, and initiated the high precision levelling for provision of reliable heights which he left to Walker's able direction [75–80].

He left the management of revenue surveys entirely to his Deputy at Calcutta, and found no opportunity to respond to Thuillier's invitation ;

Should it be in your power to afford so great an additional proof of the interest you take in these surveys by visiting any of the superintending officers in the field, it could not fail to be attended with the best results[5].

He was, however, very ready to advise and help in preparation of the *Manual of Surveying* that Thuillier and Smyth compiled for the guidance of revenue surveyors [283–4], and in 1855, with the authority of the Court of Directors, he informed Thuillier that "The Revenue Survey should be termed the Revenue Branch of the Surveyor General's Department, that branch of the office being under your immediate control and my professional supervision"[6] [537, 542]. It was, however, impracticable for either of them to exercise any control over revenue surveys in Bombay or Madras, where the local Governments had full financial powers and their own views as to the scope and organization of their land surveys [275–6, 279–80].

Waugh's administration was more peaceful than that of Everest, and there were none of the stormy passages that characterized Everest's endeavours to persuade Government to recognize the principles of high precision and uniformity of system. The Court of Directors had supported Everest in his major contentions and Waugh now found that his professional advice received respectful attention.

Like Everest, Waugh was only a Captain when he took office, but unlike Everest he was successful in his request for higher status. Before he left Calcutta in 1844 he appealed successfully that the Surveyor General should be exempt from appointment to military courts and committees ;

The office of Surveyor General has been held by a long succession of eminent men, many of whose names are well known in the scientific world, and they have uniformly enjoyed all the

[1] DDn. 549 (63), SGO. to DSG., 17–2–53. [2] DDn. 549 (63), to Mil. Dept., 19–9–53. [3] DDn. 547 (291), 13–12–54. [4] *Trig. Instns.*, [98 n.4]. [5] DDn. 472 (263–75) ; Nov. 1847. [6] CD. to B. Rev., 26–9–53 ; SG. to DSG., 16–7–55 ; DDn. 665 (80).

...privileges which are attached to the situations of other chiefs of departments; ... privileges ...conferred, not for the sake of gratifying personal vanity, but to...render them more useful as public servants. ...

For twelve years the Surveyor General of India has been absent from Calcutta on duty in the field, and his rights and privileges have been forgotten. ... Since my arrival at the Presidency I have been uniformly excluded from official entertainments[1].

Two years later he drew attention to the good progress of the survey, chiefly due to the high state of training to which the Department had been brought before I had the honour...to preside over it. The facilities which I have enjoyed by being on the spot to superintend the progress, ... render assistance when needed, and rectify omissions or departure from system, have also contributed, ... whilst at the same time the effect of immediate supervision has been to promote zeal. ...

It has all along been the intention of the Hon'ble Court of Directors...that the situation of Surveyor General of India should correspond in rank and position with that of the Adjutant General and Quarter Master General, to both of which, as well as the situations of Commissary and Judge Advocate General, the official rank of Lieut.-Colonel has been assigned [IV, 412]. ...

If it were merely a question of personal gratification, I should be sorry to occupy the time of Government with a matter affecting myself alone, but, believing...that it rests entirely on higher grounds, as effecting the efficiency of the public service, I consider it my duty to solicit that the subject should be referred to...the Hon'ble Court of Directors[2].

The Directors sanctioned "the official rank of Lieutenant Colonel" for the Surveyor General "considering the importance of the office...and the great extent of its range of duties; considering also the advantage to the public service of adding to the rank and influence of the officer selected to fill it, when, as in the present instance, his army rank shall be only that of one or more of his assistants[3]".

In 1858, Waugh asked that the offices of both the Surveyor General and his Deputy should qualify for "the brevet rank of Colonel after 3 years service as regimental Lieut.-Colonel;

No other branch of the service has so extensive a field as the Survey of India, which embraces the whole range of the Indian Empire. ... It would be sufficient to enumerate the names of General Roy, Colonels Mudge and Williams, General Colby and Colonel James of the Survey of England, of Sir Thomas Mitchell and Colonel Frome in the colonies, of Colonel Puissant in France, ... to show the pre-eminence of the Survey as a military employment. ...

The offices of Chief Engineer and Superintending Engineer, most of which are held by officers junior to myself, ... are considered to be equivalent to actual regimental command in qualifying for promotion to the rank of Colonel in the Army.

His claim was recognized under a Royal Warrant issued on 31st January 1859, but was not made applicable to the Deputy Surveyor General[4].

Unsought recognition came from Europe. In 1857 Waugh was awarded the Patron's Gold Medal by the Royal Geographical Society of London, and in 1859 he was awarded a diploma as "Honorary Associate" of the equivalent society of Berlin[5]. In a tribute to the officers of the Department he records that when I took charge of this Department in 1844, I was left by the departure of Major Renny-Tailyour single-handed to organise and superintend the vast operations which have since been carried all over India. ... Amidst the anxieties and responsibilities of so extensive a command it is a comfort...to feel that...I shall leave behind me pupils worthy to succeed to Colonels Lambton and Everest, and deserving of the complete confidence of Government.

My labours have...extended over 22 years without even 6 months leave, and though...I have on the whole been blessed with wonderful health and energy, ... so extensive a command cannot be without great anxiety and wear and tear of mind and body. ... The limits of my... duty comprise an area vastly exceeding the extent...which any of my predecessors had to superintend, ... greater than any Surveyor General in the world ever held. ...

When I contemplate the progress that has been achieved, the high state of organization and efficiency which the Department has attained, its high reputation in the world, the great improvements introduced, the number of scientific papers I have written for the instruction of the Department, ... the number of gentlemen, civil and military, whom I have trained and instructed, I cannot but feel proud. ...

[1] DDn. 452 (134–7) SG. to PS. to GG., 26–9–44; 451 (263–5), reply, 1–10–44. [2] DDn. 462 (2–51), paras 64–7; SG. to Mil. Dept., 19–8–46. [3] CD. to B. (Mil.), 15–9–47 (49). [4] DDn. 651 (146), SG. to Mil. Dept., 6–9–58; SSI., Mil., 19–5–59. [5] Waugh's acknowledgement, DDn. 643 (172), 29–7–57.

These labours have gained for me numerous flattering acknowledgements from the Government of India and the Home authorities. ... They have also been recognised by the Royal Geographical Societies of London and Berlin[1].

When the time came for his retirement, Waugh had completed nearly 42 years in India without leaving the country, and with but rare instances of absence from duty through accident or illness. He had joined the survey in July 1832 and held charge from December 1843. In December 1860 he asked permission to resign ;

I hold the conjoint offices of Surveyor General and Superintendent of the G.T. Survey which have been virtually amalgamated since 1830. Undoubtedly it is to this very amalgamation...that the Department owes it's present high standard and European reputation. ...

Major Thuillier...has been associated with me...for more than 14 years. ... We have worked together...for the good of the service in general, and our own department in particular. ... While it would be painful...that so able and meritorious an officer should be overlooked, ... his appointment will necessitate a separation of the amalgamated offices. ... The necessity for this severance would arise from the circumstance that the Major has no special experience in the details...of the Trigonometrical Survey, without an intimate knowledge of which...no man can hope to conduct the duties of that most difficult branch. ...

If, therefore, Major Thuillier's claims should be deemed of sufficient weight to justify a separation, ... I trust that the severance...will be temporary only, and that the Superintendent G.T. Survey would in turn succeed to the office as Surveyor General [10, 537].

He then discussed the claims of other officers, either for the amalgamated office or for the separated office of Superintendent of Trigonometrical Survey, and pronounced that James Walker, Montgomerie, Basevi, and Hennessey

are not only excellent surveyors, but possess the mathematical acquirements and geodetical experience necessary for the conduct of Great Trigonometrical operations of the highest order ... They are also of an age when their physical energies are fully developed, and their judgement matured by a varied experience. ...

The two first-named, viz., Major Walker and Captain Montgomerie, are pre-eminently qualified by their standing and brilliant achievements, both as surveyors and geodesists. ... It is difficult to choose. ... Captain Montgomerie entered the G.T. Survey some months before Major Walker, but the latter had for some years before...been employed...surveying the trans-Indus Frontier. ... For this reason, and in deference to his superior army rank, I have placed his name first. ... In other respects the professional merits of these two officers are equal[2].

Government appointed Thuillier to succeed as Surveyor General, and to hold the posts of Superintendent of Revenue and Topographical Surveys. Walker was appointed Superintendent of Trigonometrical Surveys, whilst the post of Deputy Surveyor General was held in abeyance. At the end of January 1861, Waugh left Dehra for Calcutta, taking Walker and Montgomerie with him[3]. He handed over to Thuillier and Walker on the afternoon of March 12th and sailed from India four days later. In his farewell order Waugh thanked all members of the Department for their loyal co-operation ;

During the past 17 years...the skill, endurance, and scientific resources of many members ...have been severely taxed, and...obstacles, physical, social, and climatic, have been overcome. ... The almost impassable barriers of the greatest mountain range in the world...have been unable to arrest the progress of the work, for the mighty Himalaya has been crossed and recrossed, and our...stations planted on peaks never before trodden by the foot of men. ...

The swampy morasses and deadly forests in several parts of India have been traversed and mapped, while many tracts of hilly country covered by primeval forests...have been covered by our stations and successfully surveyed. The desert has been crossed by our triangulation, and several series of great length carried across the Runn. ...

The accuracy and precision which have characterised the geodetical operations, the extraordinary excellence of the levelling, and the beauty and fidelity of the topographical delineations, are the best criterions of the professional merits of the...Survey Department, ... while the compilations in office, the lithographic publications, the labours of the computers, and the skilful work of the Mathematical Instrument Department, are equally deserving of praise[4].

During the period 1861 to 1877, whilst Thuillier was Surveyor General, both he and Walker took furlough on different occasions, and various arrangements were

[1] DDn. 2 (57), SG. to Mil. Dept., 17-9-60. [2] DDn. 652 (56), SG. to Mil. Dept., 8-12-60. [3] The photograph reproduced as plate 21 was taken on this occasion. [4] DDn. 701 (123), DO., 12-3-61.

made for charge of the Trigonometrical, Topographical, and Revenue branches according to the qualifications of the officers available, each branch having its own cadre of officers and assistants. On Thuillier's retirement from 1st January 1878, Walker assumed charge of the re-united offices of Surveyor General and Superintendent of Trignometrical Survey. The three branches were henceforth welded into one department that was now officially designated The Survey of India[1].

FIELD OFFICE : CLERKS

The establishment which the Surveyor General took to Allahābād in October 1844 [336] included the Registrar G. P. Webb, the head writer Andrew Olliver, and an assistant writer Blewitt—three draughtsmen, William Scott, John Cornelius and Sheikh Abdul Kadar. Radhanath Sickdhar held charge of the computing section which comprised his brother Srinath Sickdhar as Head Computer on Rs. 100, and three computers drawing Rs. 60 each, the up-country rate. There were 22 office servants with various duties.

Before the move to Digha Ghāt in 1846 [336], Blewit was replaced by Robert Scott and Harry Duhan. During the Surveyor General's absence with the Registrar in Darjeeling in 1847, the whole office was placed under Radhanath Sickdhar, and during his temporary absence on leave to Calcutta [127], George Logan took charge, having brought his field party into recess at Digha Ghāt pending his march to the Sonakhoda base. For charge of the move to Dehra Dūn at the end of the year the Surveyor General sent the Registrar back from Darjeeling, an arrangement against which Radhanath made unavailing protest.

Webb left Digha Ghāt on 8th December with a large fleet of boats passing Benares on 28th—halting at Allahābād 12th to 19th January and reaching Gurmuktesar on 25th March [IV, 170]—his party comprising 11 office assistants, 200 " public and private servants and followers", and a "guard of 1 havildar, 1 naick, and 12 sepoys", and requiring for the six stages by road to Dehra Dūn "12 horses and ponies, 39 camels, and 90 bullocks". They reached Dehra on 9th April and settled into the "Old Daftar Khana" of Everest's time on the Old Survey Road [IV, 166 ; V, 138][2].

In January 1849, Radhanath Sickdhar and the four Bengali computers at Dehra Dūn were sent down to Calcutta [355], and in October 1849—to assist with computations and other technical and administrative work at field headquarters, more especially during his own absence on tour—the Surveyor General brought in Thomas Renny, now Renny-Tailyour, and later obtained his appointment as Astronomical Assistant [380]. Waugh himself had been deeply engaged in preparing a report on the past history of the Department [345–6],

but as this...involves a thorough investigation of the old records since the year 1800, spreading over no less a period than 50 years, it has occupied a longer time than seems to have been anticipated. ... For 8 months of each year, and sometimes for a much longer time, I am obliged to be absent in the field...on tours of inspection, ... separated from my office records, and prevented from continuing the reports. ... I solicit...a little longer time...for the preparation of the reports which I should wish to make worthy of presentation to Parliament [189]. ...

Correspondence, calculations, and examinations in office have rapidly increased, and leave me little leisure day or night. ... In consequence of the addition of the...Punjab on the west, as well as the urgent demands for triangulation as basis for the revenue surveys in all directions, I have had to disperse the survey parties. ... whereby great public benefit has accrued, with immense additional labour to myself. ... I could wish to have some small portion of the assistance which my predecessor was allowed, ... not so much to relieve myself from extra labour, as to prevent the accumulation of arrears. ...

[1] Markham's *Abstract, 1877–8* (8–9) *GR Trig. 1877–8, 1878–9* (1). [2] bought from Capt. Chilcott, in Oct. 1851, bounded on N. by Bibi Goolab Jan's estate, and on S. by Mr. Haldane's ; DDn. 543 (66), 20–10–51 ; in 1865 STS. purchased for Rs. 15,000 the house and grounds of Major Stevens, spending Rs. 3,000 more on necessary alterations ; Govt. took this over, and the site is still occupied as Svy. hdqrs. ; DDn. 93 (143–212) ; 2–5–/28–6–1866 ; GBO Lib., Maps A (4), E (10).

I...propose that Captain Renny-Tailyour should be nominated Chief, or Astronomical, Assistant, the situation formerly filled by myself [IV, 356]. This measure will involve no increase of salary, while it will be a great help to me, more especially if Captain Tailyour be authorised to countersign...the bills of the nearest parties while I am absent [363]. ...

I request permission to appoint an Indexer and Writer on a salary of Rs. 100 a month[1].

Early in 1853 Renny-Tailyour resigned the service and Hennessey was brought in to help with computations [343]. The Registrar took long leave to England. The Surveyor General was as heavily pressed as Everest had been in 1838 [IV, 316–7], and the Department was almost twice a large ;

Although the want...of a personal assistant was felt...immediately on my appointment, I nevertheless determined...to endure the drudgeries of my office...single-handed. The...department, ... concentrated as it was in Bengal, enabled me...to avail myself occasionally...of the services of the survey parties which took up their recess quarters with myself. ... I derived the ablest assistance...from Major Renny-Tailyour...and the late George Logan. ... So long as these two able and highly experienced officers were attached to the Department, and a tolerable concentration of the survey parties preserved, I continued to conduct the duties of my office as well as possible. ...

The extension of the British empire...has scattered my survey parties in all directions. My tours of inspection...now extend from southern India to the northern Himalayas, and from Assam and Cuttack to Karachi[2]. ... New surveys have been set agoing. The outturn of work now-a-days exceeds that of the past by more than twice and thrice. My office at the Presidency has within the last few years created two new branches for itself—the Lithographic and Mathematical Instrument Maker's Departments. ... The office is numerically unequal to the immense mass of business. ...

Under a proper organization...the Surveyor General should have leisure...to enter extensively into geographical discussions and foreign correspondence, to publish his views, and endeavour to advance the sciences. ... I have written largely on geodetical subjects for the instruction of members of this Department, and the papers and lectures have been liberally placed at the disposal of all requiring them [282], as acknowledged by Majors Smyth and Thuillier in the preface to the Manual of Surveying for India [283–4, 338]. I have long desired to revise and collect these MS. for...publication, but it is hopeless to accomplish an undertaking of this kind amidst the distractions...I am exposed to. ...

I would propose that an extra civil assistant should be added to the G.T. Survey establishment for...assisting me, ... and I would recommend...the gentleman who has officiated as Registrar for the past two years during the absence on sick furlough of G. Webb Esquire, who has now returned. ... Mr. Duhan during the past 10 years has accompanied me in all my wanderings over India. ... To his untiring industry and assistance I am indebted for preventing accumulation of arrears. ... His private leisure has been cheerfully...surrendered to midnight toil. ... On Mr. Webb's return Mr. Duhan reverts to his former situation in my office, the substantive salary of which is Rs. 120, making with field allowance Rs. 180 a month [IV, 333, 337 n.5][3].

Duhan was accordingly posted to fill a situation as "junior civil assistant", and as such employed in the Surveyor General's field office. The clerical vacancy was transferred to the Calcutta establishment.

FIELD OFFICE : DRAUGHTSMEN

The Drawing Office at Dehra Dūn continued under charge of William Scott, son of the Madras stalwart [III, 314 n.2, 501–3[4]], and in 1858 he succeeded to the office of Chief Draughtsman on the death of John Graham. He was

a most zealous, able, and indefatigable draftsman, and...in fact superior to his predecessor. ... The wonderful accuracy of all work passing through my field office is due to his unremitting care...in the examination of the numerous and elaborate maps which pass through my hands. To his artistic talents the degree sheets of the Himalaya and the Kashmir map owe much of their high finish [318–9]. ... As compiler he is unequalled in accuracy and judgement.

His industry is such that he frequently works from 6 o'clock in the morning till dark. ... I regret that the salary drawn by Mr. Graham has been reduced on the succession of Mr. Scott,

[1] DDn. 542 (18), SG. to Mil. Dept., 6–5–50. [2] but Waugh made no inspections to s. India or to Cuttack. [3] DDn. 651 (80), SG. to Mil. Dept., 1–12–56.

who is a more able man, and very inadequately paid, ... especially when compared with salaries granted to other uncovenanted servants in employments not requiring half the educated ability, skill, and knowledge, ... and I would now most respectfully urge that the same substantive salary of Rs. 450 per mensem as the late Mr. Graham drew, should be passed to Mr. Scott[1]. The promotion was authorized and Scott continued as Chief Draughtsman at Dehra Dūn till his death in 1873 at the age of 60.

His younger brother Robert had long been employed in charge of stores and on his death in 1874 Walker writes that

Mr. Robert Scott, whose good services in the correspondence office and as general storekeeper it has always been a pleasure to acknowledge, ... died on the 12th September after a long and painful illness. *Nearly 30 years service ; hard-working, simple-minded, and ready to oblige* everybody, "good old Robert" will long be remembered[2] [IV, 441].

John Cornelius had drawn the maps of Norris' survey of Nāgpur, and had joined the Surveyor General's office at the close of that survey in 1831 [III, 93]. He retired on pension in 1852 and died at the age of 80 as also did his son, Walter John, who followed him in the department [359].

Of Joshua Baness who joined in 1856 Waugh writes to Thuillier ;

I have got a new draftsman here, a European with brains, pluck, and stamina, and great aptitude, who I think will be an acquisition. ... I will send you a specimen of his military drawing, and I am sure under a rigorous man like Scott he will turn out a first-rate geographer and draftsman, *indefatigable like your model Mr. Smith, whom all speak so highly of* [357]. ... I think if you saw Mr. Baness and tried him you would approve. Even that fastidious man, W. Scott approves, and it is seldom he admits that any...can do much[3].

Baness joined the Rāwalpindi party two years later and after several years as field surveyor became Chief Draughtsman in Calcutta in 1876 [430].

We have many specimens of the beautiful draughtsmanship of the different Indian draughtsmen. Sheikh Abdul Khadar who came up with the field office in 1844 died in Dehra in 1860 [IV, 337]. Ghulam Khadar came up from Calcutta in 1855 being one of the few to volunteer for service up country [291].

From 1852 the field office enjoyed long week-ends ;

26th May 1852. The members of the Department at headquarters [having requested] that Saturday should be made a holiday, and...[being] willing to work extra time on the other five...days of the week, ... the Surveyor General's field office...will close on Saturday till further orders *and will open on other days* at ¼ to 10 precisely closing at ¼ past 4[4] [502].

21st May 1855. The hours of business at the Surveyor General's field office [Mussoorie] will until further orders be from 9¼ A.M. till 4½ P.M., Saturdays and Sundays excepted.

Members of the Department wishing to obtain an interview with the Surveyor General will knock at the door of his study, and wait till permitted to enter[5].

FIELD OFFICE ; COMPUTERS

After the Chief Computer had left for Calcutta in January 1849, Hennessey, Peyton, and other assistants were brought in to Dehra Dūn from time to time, and employed under Renny-Tailyour [341] on various computations, which included those of the Maluncha Series and of the Surveyor General's route through the Punjab [337]. During 1852 computations also covered meteorological and other observations from Calcutta, Dehra, and Banog observatories [137–8][6].

After Renny-Tailyour left in 1853 Hennessey held charge of a small computing section, and work was then taken up on the North-East Longitudinal series and the snow peak observations [90–1, 128]. Many of the newly joined assistants spent some months in this section, and Hennessey lectured on subjects such as "vernier theodolites" [90 n.6, 157, 410]. Strange spent the rains of 1855 at field headquarters, completing computations of the Great Longitudinal series, and exercising general supervision in his capacity as Astronomical Assistant [380].

Besides computations the computing section had to

[1] DDn. 652 (5), 6–10–60, para 85. [2] *GR. Trig. 1873–4* (36), JTW., 15–12–75. [3] SG. Fd. Corr.; to DSG., 26–9–56. [4] DDn. 455 (158), DO. [5] DDn. 14 (29/16). [6] DDn. 565 (159), Report 1–1–53.

examine candidates for the Department—...Take barometrical and thermometrical observations for the Messrs Schlagintweit five times a day and 25 times on the 21st of each month. —Keep the chronometers going, and to shew mean time—Receive in store, preserve in good order, and issue as required, upwards of 24 different kinds of forms—...Train young surveyors in computations and the use of instruments. ...

With only three native surveyors it is not possible to meet both the miscellaneous duties and the regular computation of arrears. ... Arrears must go on accumulating unless additional aid be afforded[1].

Three Indian boys were then recruited from up-country colleges for training as computers or surveyors [360][2].

In his final report Waugh records that

the computing party at my headquarters have made great progress in bringing up the arrears of computations and current duties. The N.E. Longitudinal series report has been brought up and is nearly ready for issue. The N.W. Himalaya series is also in a great state of forwardness.

The calculations connected with the base-lines of Chuch and Karachi have been completed, and 3 copies of the account of those operations have been prepared, one of which has been transmitted to the India House, and the other to the Surveyor General's office Calcutta. The field computations of the several parties have also been examined, and data for survey operations furnished. Upwards of 20 examinations for entries and promotion have also been conducted. In these laborious duties I have been greatly assisted by Mr. Hennessey[3].

Walker reports later that the distance of the computation office at Calcutta

had entailed the formation of a small office at headquarters under...Hennessey, ... composed of native surveyors and newly joined sub-assistants, who thus had an opportunity of being rigorously trained in the theoretical...portion of their duties. This little office has lately completed the triplicate ms. copies of the General Report of the N.E. Longitudinal triangulation between Dehra Dun and Purnea in two thick imperial volumes; ... also revising the triangulation computations of the N.W. Himalaya series, and levelling computations[4].

The section was formally established under Hennessey from 1st January 1861, and comprised sub-assistants Charles and John Wood and Joseph Burt, and three Indian computers, Cheetur Mull, Ganga Prasad, and Chedama[5]. On the retirement of Radhanath Sickdhar in 1862 the Calcutta office was brought to Dehra Dūn, and except for Bholanath Mauzamdar all the Bengali computers were replaced by up-country men [356, 360][6].

CORRESPONDENCE & REPORTS

Like Everest before him, Waugh found that the load of routine correspondence was an increasing handicap to his professional work, though his Deputy at Calcutta had considerably more responsibility than in Everest's time. Thuillier corresponded direct with Government regarding all headquarter offices at Calcutta. From time to time, as during the troubles of 1857, he took over responsibility for the field parties in Orissa and Assam.

One of the measures introduced by Everest, and still maintained, was the use of half-margin letters, the field unit submitting its note in duplicate, and leaving the half-margin for the Surveyor General's reply [IV, 344][7]. Waugh started separate files for each field unit ;

17th December 1856. The Surveyor General has experienced for some years great inconvenience from want of methodical arrangement in the Surveyors' letter book. Each Survey or Series should have had a separate book, so that on the completion of a work the letter-books to and from, containing all instructions, correspondence and discussions, could be made over to the computing and accounting departments for the preparation of its history and statistics. ... A new book should be opened hereafter for each new Survey[8].

Both Waugh and Everest were themselves guilty of remarkable prolixity in their letters, whether on professional or administrative subjects, giving lengthy explanations of the minutest detail. The need for such explanations was the more

[1] DDn. 673 (38), from Hennessey, 14-10-56. [2] @ ₹ 60 each. [3] DDn. 594 (361), Report 1856-60, 6-10-60. [4] *GR Trig. 1851-2* (7). [5] DDn. 648 (433), DO. 10-1-61 ; Ganga Prasad became Ch. Compr., 1865-99. [6] *GTS.* II (xxiii-iv); DDn. 332 (11), 2-4-63. [7] DO. 6-2-44. [8] DDn. 14 (29/16).

essential because of the lack of text-books and handbooks. In 1856 the Surveyor General pointed out that correspondence was

now growing so bulky that it is difficult to read, far less to answer, all that comes in. ... If the innovation is longer tolerated it will be necessary for the Surveyor General to apply for an increase of office strength. Some of the narrative and other Reports are so unwieldy, tedious, and encumbered with extraneous matter, that it is difficult to condense them for the information of Government, and out of the question to submit them entire. ...

The business of the Department is essentially professional, and neither requires long correspondence, nor are survey parties constituted to admit of prolixity being indulged. Every long rambling letter wastes the time of one Surveyor in composing, and another in reading it[1].

Of all the surveyors none was a greater offender than Strange who poured in a stream of lengthy reports, both from the Great Longitudinal and the Coast series. Waugh calls attention to his orders on the subject ;

Your report...in giving an account of one of the smallest season's work on record extended to a very inconvenient and unusual length, ... necessitating a review of corresponding length from myself. I entered into this wearisome discussion with extreme reluctance, and had fully hoped that my letter would set all doubtful...matters at rest.

You may judge therefore how little I could have expected to receive a long and tedious rejoinder. In the Report itself you had not stinted yourself in space, ... and I can...only regard another lengthy letter commenting on my review as equally unnecessary [362]. ...

Every well conducted series should be so much a matter of routine that a narrative...ought to require no comment...on my part. ... I have a right to expect that the annual reports... should...not...necessitate my...writing elaborate remarks. ... The remarks offered by me...were penned after careful deliberation. ... I must...insist on my opinion...being...undisputed[2].

A departmental order was issued on the vexed question of courtesy titles ;

The Civil members of the Department, in the preamble of their letters, are to use their Christian names and surnames only, with their rank in the Department subjoined, without applying terms of courtesy...such as Mr. or Esquire, but when addressed officially by other members of the Department they are to be styled Esquire. The following example of a preamble will render this clear ; viz.,

From John Peyton, Chief Civil Asst. G.T. Survey, in charge Coast Series, to Charles Lane, Esqr., Civil Asst. G.T. Survey, in charge Rahoon Meridional Series.

On all maps, plans, documents, etc., the term Mr. or Esqr., will not appear, ... but the Christian and surname only, with the rank and designation, thus ; the principal triangulation executed by James Nicolson, Civil 2nd Assistant in charge Assam Longitudinal Series. The approximate triangulation by Charles Shelverton, sub-assistant, G.T. Survey[3].

It had from the earliest times been a standing order that every surveyor should submit a narrative progress report on his work every month, with an annual report on 1st October each year. These were quite distinct from the technical professional report that each party of the Great Trigonometrical Survey submitted after the close of his operations [127]. A summary of these narrative reports was submitted annually by the Surveyor General with his own comments, as called for in letter No. 102 from Court of Directors, dated 6th November 1833. The Surveyor General had also to submit a condensed report on the work of the Department every three years, commencing with the period 1850–3[4]. The printing and publication of these reports was later introduced separately for Trigonometrical, Topographical, and Revenue Surveys. The first published report on Trigonometrical Surveys was that for the three seasons ending 1858–59 — on Topographical Surveys, 1860–62 — Revenue Surveys, Bengal, Lower Provinces, 1852–3. These separate reports continued till 1877, the close of Henry Thuillier's period as Surveyor General[5].

A special report was submitted in 1850 entitled, *Report on the Progress and Expense of the Great Trigonometrical Survey of India, and a Sketch Map of India, showing the Extent of the Great Trigonometrical Survey up to the year 1849–50*, and signed by Waugh at Dehra Dūn on 20th October 1850 [III, xxi ; V, 189[6]]. It gave

[1] DDn. 648 (311), DO., 1–11–56. [2] DDn. 696 (262), 1–4–57. [3] DDn. 600 (126), DO. 26–7–55. [4] DDn. 704 (19), B to CD., 25–11–53 ; CD. to B., 22–3–54. [5] *IO Cat.* (28–30, 61–6) ; *Imp Gaz.* IV (481–507), Account of Survey of India ; DDn. 332 (3) ; STS., Report 25–8–62 ; *Roorkee Papers*, I, 1863–4 (181–200, 467–79). [6] *PR.* ; *IO Cat.* (27–8) ; "Ordered by the House of Commons to be printed", 15–4–51. Extracts pub. *Roorkee Papers*, II–LXXXI (285–300, 398–407 *et seq.*).

an account of the start of the Trigonometrical Survey under Lambton and of all regular surveys completed and in progress up to the year 1850. It included a statement of expenses [347]—a summary of Blacker's notable letter of 11-8-24 [III, 241 n.3]—a list of 40 sheets of the Atlas of India completed, and 13 in progress, signed by John Walker on 2nd April 1851 [309] and a statement of all Districts and States with estimate of their areas and population [307–8].

Waugh concludes with a tribute to

those officers who have been most conspicuous for meritorious service in connection with the accurate geography of India. ... Colonel Lambton and Colonel Everest stand pre-eminently above all others...and their names are held in affectionate remembrance in this Department.

To these may be added, Captain Renny-Tailyour, ... Captain Jacob, ... Mr. G. Logan, all of the Trigonometrical Survey—...and Colonel Wilcox, ... the late General Hodgson, Colonel T. Oliver, Major Herbert, and Major W. Brown of the old revenue survey, together with Captain Thuillier, the present Deputy Surveyor General, whose abilities are of a high order, and Captain R. Smyth...both of whom are ardent admirers of accuracy. In the Madras Presidency, Captain Du Vernet, the late Captain Garling, Major Ward, and Captain Snell.

The list omits Colin Mackenzie and Valentine Blacker.

During Waugh's stay at Dehra Dūn he brought up from Calcutta the whole series of correspondence volumes, both of the Surveyor General of Bengal and of India, and of the Great Trigonometrical Survey, dating from the earliest times. Fieldbooks and original surveys were left in Calcutta. There was an unfortunate occurrence in 1846 when about 140 fieldbooks or journals at Calcutta were lost [322–3]. The correspondence records were split up after Waugh's retirement; all the Surveyor General's correspondence from 1788 to 1830 being sent down to Calcutta, as well as letters to and from the Surveyor General and topographical parties. The letterbooks of the G.T.S. from 1830 were retained at Dehra Dūn[1]. All these records, with the exception of those destroyed by the Calcutta climate, have now been lodged with the National Archives of India at New Delhi.

FINANCE

Strict control was maintained by the Audit Department over the expenditure of all branches of the Surveyor General's department. Government orders covered all salaries from the highest to the lowest, and the numbers employed on every duty. In some units, such as revenue survey parties, a gross monthly sum was laid down for the unit, or for each head of expenditure, and the executive officer was allowed to vary the numbers of individual and their rates of pay, so long as he kept within the amount sanctioned [IV, 347 ; V, 361, 453].

Revenue Surveyors were allowed a fixed sum, Rs. 200 a month for parties of double establishment [IV, 216], for contingent charges, from which they had to cover all expenditure outside the salaries [IV, 346–7]. Other surveyors were allowed to submit contingent bills under the Surveyor General's previous sanction [IV, 330][2]. The Surveyor General writes to Hill on his taking charge of the Coast Series ;

You are allowed to charge for all extra expenses, bonafide incurred, in a monthly contingent bill which, agreeably to the orders of Government dated 15th April 1840, must be submitted for my countersignature [IV, 330]. ... These extra charges will consist of such items as aid of inhabitants in building platforms, carrying the sick and their loads, and generally all public contingencies, and are to be universally supported by sufficient vouchers.

On the 1st March and 1st September you will...furnish half-yearly returns of progress and expenses, together with one of the instruments placed at your disposal. The most scrupulous care will be required...to preserve these instruments in a state of efficiency, and to protect them from accidents, for, if they are stolen or injured...unless it can be clearly shewn that such has occured in spite of all necessary precaution on your part, you will be liable to pay the full amount at which they are debited on the Accountant General's books[3] [IV, 140, 330].

Surveyors had to meet from their salaries all expenses incurred when travelling from place to place ; travelling allowances were not introduced until after 1861.

[1] DDn. 6 (5) SG. to STS., 3-5-61 ; 7 (64–110), 25 (10–32), STS. to SG. 18–5-to 5–9–61. [2] DDn. 547 (343–9), SG. to Mil. Dept., 21–7–55. [3] DDn. 600 (194), 1–9–45.

Such expenses could be particularly burdensome when working in the mountains, as recognized at the time of Hodgson's survey of 1815–8 [III, 347–8], and special allowances were authorized for the North-West Himālaya series [35, 375, 429–30].

In 1848, for their report to Parliament [345 n.6], the Directors called for a statement of the area covered by the Trigonometrical Survey, and its cost. The Madras Government reported a total of 1,65,688 *pagodas* for the period 1800 to 1818. "The pagoda has been reckoned at 42 fanams up to the year 1806–7, and from the year 1807–8 at 45 fanams [I : 278 n.7 ; III, 108 n.4, 213 n.5][1]. Waugh gave the full cost from 1800 to 1848, to be "Company's rupees 34,12,787"[2]. He discusses the cost of each trigonometrical series, and disputes the calculations of the Auditor General, in whose statement is included a charge for...the cost of feeding Government cattle. ... The cattle lent to this department in times of peace, and always withdrawn during war, have added no extra charge to the public service, and the Survey cannot fairly be debited therewith[3].

As an example of the tight control of expenditure that is repeatedly stressed in the Survey records, it is recorded that the Lieutenant-Governor of a Province was unable to sanction the cost of one extra sweeper @ Rs. 4 a month ; the charge had to go before the Governor-General in Council[4].

In 1860, Waugh submitted to the Military Department his first annual budget, that for 1860–61 ; this made no provision for revenue survey, which was the business of the civil Revenue Department.

In submitting this document, exhibiting an aggregate sum of rupees five lakhs, sixty two thousand and fifty four rupees and three annas (Co.'s Rs. 5,62,054–3–0), for the approval... of Government, ... I have endeavoured to draw it up with every regard to economy that the maintenance of due efficiency will permit. In the column headed "Decrease"...a large amount (Rs. 1,23,416–2) will be dispensed with this year. ... I hope to shew a further considerable saving on this estimate in the budget for the year 1861–62.

The preparation of this, the first budget, ... has been...delayed owing to the necessity of procuring estimates from the different parties under my control dispersed over India[5].

[1] DDn. 541 (100), 5–11–49. [2] DDn. 542 (153), *PR.* (29–30), 20–10–50. [3] *PR.* (175). [4] Keene (173). [5] DDn. 651 (155), 18–6–60.

CHAPTER XXII

DEPUTY SURVEYOR GENERAL & CALCUTTA OFFICES

Deputy Surveyor General — Superintendent, Revenue Surveys — Calcutta Premises — Correspondence Branch — Drawing Office — Computing Office — Observatory — Lithographic Press — Mathematical Instruments — Nominal Rolls.

ON return from furlough on 15th March 1844, Robert Wroughton—first appointed to revenue surveys in 1821 [III, 516]—assumed duty as Deputy Surveyor General and Superintendent of Revenue Surveys in the Bengal Presidency[1] [336]. His immediate task was the publication of quarter-inch district maps compiled from revenue surveys and correctly adjusted to G.T.S. control [295, 312]. His health was far from good, and after a month's leave in 1846[2] he took long leave on medical certificate in February 1847, sailing on 9th September for "Mauritius and Van Diemen's Land" [Tasmania]. He returned but little benefited by this leave, and at once took furlough [IV, 476].

Henry Thuillier, recently returned from furlough [IV, 471], having taken over charge in February 1847 was confirmed as Deputy Surveyor General from April 1849, holding the post with distinction until he succeeded as Surveyor General in March 1861 [340][3].

Thuillier had been a most successful revenue surveyor [IV, 199–200, 471; pl. 21], and now proved a first-rate business man. In addition to charge of the ever expanding revenue surveys [352] he brought the Surveyor General's offices to a high state of efficiency. From time to time he took over the administration of such field parties as were temporarily beyond the Surveyor General's reach [143, 349 n.4, 537]. At all times he maintained cordial relations with his chief, to whom he was a tower of strength.

He successfully met the vast expansion of map drawing and compiling, and introduced the systematic storage of maps and sale to the public [323–4]; the same expansion of field surveys redoubled the work of the Mathemetical Instrument Workshop and store. The most important change he introduced, however, was the transfer of litho-printing from the Government Press to his direct control, to become a map-printing unit of the Surveyor General's Department. No sooner had the first presses been installed than he was called upon to print the first postage stamps ever to be produced in India. Neither he nor his staff had any experience of such printing, but by the ingenuity and resourcefulness of Thuillier and his head assistant Mariano Smith more than six million stamps were issued during 1854–5 [332–5]. On his application for rise of pay and promotion to the rank of Major—several of his departmental juniors having already reached that rank—the Government of India admitted that his salary,

viz., Rs. 1,343–10-0 per mensem (military pay and allowances Rs. 493–10–0—staff salary as Deputy Surveyor General, Rs. 500—Superintendent Mathematical Instrument Department, Rs. 100—...Superintendent of Revenue Surveys, Rs. 250) is inadequate to the duties devolving on you. It is not competent to the Government of India to sanction any increase of salary for your ordinary duties, but the duty of superintending the Postage Stamps, a difficult and laborious undertaking which you have discharged to the entire satisfaction of the Government of India, has no connection with your regular duties, and...His Honour in Council...has been

[1] nominated DSG., GO. GG., 15–12–43. [2] when Arthur Sanders [IV, 464; V, 325] acted for him from 10th July. [3] doing duty continuously from Feb. 1847.

pleased...to grant you an allowance of Rs. 350 a month from the time when you first undertook the duty in February 1854...until...the arrival of the English stamps[1].

They referred to the Directors who granted him " the official rank of Major " whilst employed as Deputy Surveyor General, but allowed no further rise of pay[2].

In pressing for increase of clerical staff, both for Dehra Dūn and Calcutta, Waugh pointed out that he had received repeated representation from my Deputy at the Presidency pointing out that the portion of my office under his charge has long been unable to overtake the work devolving on it. ... What with the Revenue Survey, ... the Drawing Office, the Mathematical Instrument Maker's Department, and the Lithographic Office, my able Deputy, like myself, has the work of a dozen men to perform. ... Being similarly situated...I can well sympathise. ... My talented...Deputy...however has a head...assistant attached to the Revenue Branch. ... The present incumbent [Hoppner], though an old surveyor, has to acquire all his experience in office, whereas Mr. Daniell his predecessor who died last year is described...[as] an able and very industrious man of business [352][3].

A great deal of work was thrown on the Calcutta offices by the disturbances of 1857–8[4], as Waugh noted when commenting on the Revenue Survey reports ;

In my position...as professional head of the Department [338] a few remarks...may be acceptable to...the officers of your Department. ... I have carefully perused these reports, ... and am in every way satisfied with the results. ... The large savings...effected in every branch shew that you regulate the Department...with economy and efficiency combined.

Your own labours in connection with the rapid production and circulation of the maps of the disturbed districts during the rebellion have...been acknowledged by the Hon'ble the President in Council. ... Without maps...our troops would have been embarrassed. ... I...express approbation of your management of the Surveyor General's Office, and...state the high opinion I entertain of the...services rendered by Mr. James and Mr. Walter Graham [353–4][5].

To Government he commends Thuillier for his exertions in the publication and supply of maps to all detachments of troops, and to officers and departments employed in quelling the revolt. ... Major Thuillier's foresight in preparing, and energy in publishing, these compilations are highly creditable to him and the lithographic branch [314–5, 321, 483][6].

In October 1859, Major Thuillier obtained two months privilege leave for the purpose of visiting my field office. During this absence Major Walter Sherwill acted as his locum tenens.

Before he took this leave the offices were honoured by a visit from the Governor General himself, and by an appreciative letter from his Military Secretary commending "the orderly and excellent manner in which...the work is executed, with appliances in many respects inadequate"[7].

SUPERINTENDENT, REVENUE SURVEYS

Thuillier was directly responsible to the Revenue Boards at Fort William, Agra, and Lahore for the control, both professional and administrative, of all district surveys. These included surveys in Assam, the Lower Provinces, Bihār, North-Western Provinces (which latter administered the Central Provinces and Rājputāna) and also the Punjab and Sind. He was even expected to direct revenue surveys in Arakan and the Malay States [244].

During 1851 he found that the Board at Lahore was beginning to interfere in the posting and transfer of officers and asking for closer control themselves ;

Some measure seems...to be urgently required, not only for strengthening the survey establishment, but for infusing alacrity into them. ... The supervision of the Deputy Surveyor General residing in Calcutta over establishments in the Punjab cannot be more than nominal. No ability—no experience—can compensate for the disadvantage of remoteness. ... The Board could wish either to see appointed a Superintendent of Surveys for the Punjab, or to have the control themselves[8].

Thuillier was stung to the quick and thought that these remarks were decidedly adverse to myself, and...the superintendence hitherto exercised. ... It is far from my

[1] DDn. 641 (145), 7–9–55. [2] CD. to B., 7–5–56 (19–20); GO. GG., 25–6–56; SG.'s DO., 4–7–56, DDn. 696 (215). [3] DDn. 651 (80), SG. to Mil. Dept., 1–12–56 (para 31). [4] About this time control of Assam & Orissa parties was temporarily deputed to D.S.G. [5] DDn. 666 (34), SG. to DSG. 23–5–59, [6] DDn. 652 (5), Report, 1856–9, 6–10–60. [7] Inspection on 27–9–59 ; DDn. 668 (199). [8] DDn. 562 (177). Bd. of Admin. to Govt. of India, 23–9–51.

wish to urge a word against the principle...that a Superintendent...on the spot is better than one located in Calcutta, ... but it is stated that the supervision of the Deputy Surveyor General ...cannot be more than nominal. ... Much dissatisfaction is expressed at the present state of Lieut. Blagrave's establishment, and with its conduct during the first season [270–1].

During the four and a half years which I have exercised supervision over the Punjab and Sutlej surveys, I am by no means prepared to allow that my...control has been merely nominal. ... The several operational reports...submitted to the Government of India...have called forth the thanks of that Government, a return not likely to be made for a mere nominal supervision.

In all local or revenue matters I have always understood the several survey parties to be completely under the control of the Board, ... and...the wishes...of the Board have invariably been adopted and acted up to with the utmost...promptitude. ... I endeavoured to instil into the minds of the executive officers the...Board's wishes and orders, and...everything has been done...to proceed with vigor and efficiency. ... What is now complained of is of a very temporary character, caused by deaths and illness common to humanity, and...with fair exertion and foresight on the part of the Surveyor, and due co-operation with the Settlement Officer, the combined duties of Settlement and Survey may proceed without interruption[1].

The Board assured Government that they imputed no blame to the Deputy Surveyor General, who had "done all that was in his power ; ... but no superintending authority placed so far off...can effect that which might be done by one on the spot". They had found the surveyors at fault, and concluded that ; " if Captain Thuillier were on the spot...he could not only understand the cause, but might probably be able to remove it"[2]. Government could not agree, however,

to have a separate Superintendent of Surveys...stationed at Lahore. ... All that is required... is a different division of the duties...so that while the scientific department should remain as at present under Captain Thuillier, the administration should be transferred to the Board.

Captain Thuillier has...given so much satisfaction in his management of the surveys that it is obviously desirable to retain as much of his control as can be exercised from Calcutta with efficiency. ... The Governor General is pleased to direct that the scientific portion of the work shall remain...under the Deputy Surveyor General, who will continue to give orders on all such points—will arrange...supply and repair of instruments—will examine and record the calculations and maps—and do all that is needful towards the preparation of a...geographical map.

All other matters will rest with your Board, who will recommend officers and uncovenanted assistants to Government for appointment, promotion, and charge of surveys. ... You will have power to authorize Surveyors to arrange details of work provided the authorized limits of annual expense be not exceeded. Your Board will pass contingent bills and other accounts, ... and...perform...all the duties...except interfere in...scientific detail.

Your Board, ... personally consulting...the surveyors, will be able to meet immediately all local and temporary difficulties. ... You can also expedite the survey ; ... you can by personal examination see whether Surveyors in charge are up to their work, or whether they devolve their duties on their assistants. ... You will to be able to...ensure zealous co-operation with the Revenue Officers. ... Copies of all orders issued to Surveyors...should be forwarded for the information of the Deputy Surveyor General[3].

Thuillier by no means approved of all the orders of the Board of Revenue at Fort William. He disliked the transfer of the *khasrah* surveys to the control of the Civil Superintendent [300–1]. He pointed out "that the Revenue Officer being styled Superintendent of Surveys...leads to considerable confusion". The Board suggested that confusion might be avoided by prefixing the word "Civil", or,

as a far simpler solution, ... that the Deputy Surveyor General should abandon the use of the title. ... The Deputy Surveyor General superintends the revenue branch of the Survey as one of his principal duties, but that fact...no more necessitates the use on his part of the title of Superintendent...then does the fact of a Revenue Commissioner superintending settlements require him to be called Superintendent of Settlements. ...

There ought to be no difficulty in defining the limit of the Superintendent's power of interference with the Surveyor, and they will endeavour to do so. As a general rule in all matters strictly professional the Surveyor should take his orders from the Deputy Surveyor General, but in all other matter he must attend to instructions received from the Superintendent. With two officers so continually in contact with each other, if one is not placed under the other, there must...be constant disagreements.

[1] DDn. 562 (173), DSG. to Bd. of Admin., 16–9–51 ; 624 (62), to SG., 5–4–56. [2] DDn. 562 (179), Bd. of Admin. to Govt., 8–10–51. [3] ib. (181), FD. to Bd. of Admin., 1–12–51.

The Superintendent must, therefore, be looked upon as the officer at the head of the party, but...abstain from...dictation, and...regard himself rather as the channel of communication between the Board and the Surveyor than as possessing authority over him.

The Board...regret...the tone of asperity and exaggeration adopted by Captain Thuillier. ... The result must be the entire absence of cordiality between those whose harmonious co-operation is indispensable[1].

They held to their policy of giving more responsibility to the Civil Superintendents, and asked that the new system should be given time to prove itself. In due course the duties of these Superintendents were carried out by Settlement Officers.

After succeeding as Surveyor General Thuillier told the Government of India that his reports on the Revenue Survey operations

to the respective local Governments have always been printed annually by the civil Department for general information and circulation. ... But unfortunately this branch...has been so divided and made subordinate to the various local Governments that my reports have necessarily partaken of a disjointed...character, and the general results of the working of a large department scattered from Sind, the Punjab, N.W.P., Bengal, to Arrakan and Nagpore, have not appeared to that advantage which...is due to a great national work.

It is most difficult to control a department so circumstanced, and to exhibit the results in a popular manner[2] [2, 5-80, 292-396].

CALCUTTA PREMISES

In 1838 the Surveyor General's offices had been moved from No. 21 Chowringhee to No. 2 Chowringhee Lane, the observatory being left in the small building specially built for it in the grounds of No. 21 [IV, 114, 332]. In 1846 Wroughton recommended a move to new premises in Hungerford Street, but when Thuillier took over the following year he decided to stay on ;

The landlord...agreed to make a thorough repair and reduce the rent to Rs. 250, which I consider far better than moving to such a distance from the Observatory and Instrument shop. ... At my suggestion a fine skylight has been made in the large central room upstairs and a verandah built below. ... These repairs are now nearly completed. In the meanwhile the office is removed to a house in Kyd Street, whilst our Revenue Branch is in the Sudder Board House [No. 21]. When we get back all together I shall be able to get on much better[3].

In May 1849 he was able to accommodate the computers from Dehra [355], though this caused serious overcrowding, especially with

the bulky records fast increasing to the extent of about 70 folio volumes per annum...in addition to a large stock of instruments belonging to the Great Trigonometrical Survey. The multiplication of the maps by lithography and their deposit in the Revenue Survey Office for sale [322-4] likewise adds greatly to the want of room. ...

The rent heretofore paid for this house was Rs. 300 per mensem...reduced in 1847 to 250. It has been occupied...since 1838, and had never been repaired until 1847. ... The rent is still far above its value. ... The old office No. 35 Park Street, one of the finest 3-storied houses in Calcutta, ... is now available [IV, 332]. It would make a most excellent...office as well as observatory. ... The position of that observatory is trigonometrically connected with the whole of India, and the number of astronomical observations taken by Colonel Blacker... (entirely lost by the removal) may be redeemed.

The rent...on a lease of three years is only Rs. 320 per mensem which is extremely moderate. ... Except for its propinquity to the burial ground it would be worth Rs. 500. For an observatory the situation could not be better, whilst the great height of the house adds to its advantages and commands a fine view of the whole country, and particularly of the Fort semaphore for shewing mean time[4].

The move was completed on 19th. November 1849. No. 35 Park St. was identical with No. 37 occupied by Blacker in 1824 [III, 187, 311 ; IV, 332] and the observatory was re-erected in its old position at the top of the house.

In 1857 Thuillier once more complained of overcrowding ;

On first entering this spacious mansion, one of the largest in Calcutta, ... ample room... was found, but by degrees with continual increase ... and above all by the enormous influx

[1] DDn. 562 (146), Rev. Bd. LP. to Rev. Dept., 11-7-51. [2] DDn. 21 (100-1), 30-1-62 ; cf. Report to S.G. 624 (62), 5-4-56. [3] DDn. 472 (113-8), DSG. to SG., 3-7-47. [4] DDn. 480 (90), 29-5-49.

of records belonging to the Revenue Surveys and...the General Department...caused by the extension of surveys all over India, as well as by the rapid strides of the lithographic press in multiplying maps, even this house is becoming very full. ...

On the lower floor there are 24 assistants and draftsmen, with the large tables necessary for their work, besides the very bulky almirahs containing the records, and on the second floor 28 assistants and draftsmen, in addition to the records, besides candidates for employment. ... The verandahs are...used for the dufteries. ...

No Government employees in Calcutta enjoy such peculiar privileges...as the Computing Department. No person can enter the third floor without being struck at once with the ease and comfort in which they are placed, and...I cannot concur with the Chief Computer...that he cannot entertain three additional computers simply for want of office room[1].

In 1860 the rent was raised to Rs. 400 p.m. Relief was afforded by the move of the lithographic press to No. 10 Middleton Street, and by the transfer of the Computing office to Dehra Dūn, but the remaining offices continued to expand, and the Surveyor General reported in 1862 that

so great has been the influx of maps and large folio volumes of village plans of the Revenue Survey, not only of Bengal but of the N.W.P. and the whole of the Punjab, ... that we have neither space on the two lower floors for the necessary almirahs, ... or proper accommodation for the number of hands employed. ...

The ground floor...is used for the General Department, or Surveyor General's Branch, which is the geographical depot for all India, and is made to serve for the correspondence clerks, the draftsmen, and all the records, both ms. and printed. ... The multiplication of maps...by engraving and lithography has caused an immense addition to our records. ...

On the second floor the whole of the Revenue Branch...is located ; correspondence, computing, drawing, and records. This office has been weighted with almirahs and racks to such an extent as to be dangerous to the safety of the floor, and the Agents...have already remonstrated on the subject. Yet every year our Revenue Survey parties are producing many thousands of square miles of survey[2].

In 1882 the whole office establishment of the Surveyor General's headquarters moved into specially designed new buildings erected in Wood Street[3].

CORRESPONDENCE BRANCH

When the Surveyor General moved up country in October 1844, he left only two clerks for his Calcutta offices. On the retirement of George Barnes in 1855 [IV, 349], one of the draughtsmen was brought in to help ;

Mr. A. C. Cunningham[4], a young man of good education and excellent business habits, who has undertaken to bring up the arrears...and attend to the duties of the correspondence department, which has fallen into sad arrears, at his leisure hours before and after office.

Cunningham was allowed pay as writer in addition to his salary in the drawing branch, and on Duhan's promotion two years later to be sub-assistant at Dehra Dūn [342] was appointed Head Writer at Calcutta ;

This...will afford a slight increase to the small salary drawn by...Mr. A. C. Cunningham, who draws at present Rs. 45 from the Correspondence, and 60 from the Drawing, Branch. ... This, though it meets in a measure the emergency of the case...to provide for current work, will not, I fear, place the Department on a permanently satisfactory footing. ...

Under the present system the very scanty means at command preclude the possibility of any attempt at indexing, docketing, and proper registering of letters, in consequence of which a vast deal of time is lost in searching for a single reference, and serious inconvenience is being constantly felt by the difficulty of finding papers when urgently required [344–5][5].

Cunningham moved to the Revenue Survey office in 1862[6] and retired on 17th July 1886, after 30 years service, "but lived only three months to enjoy pension".

On the Revenue side Thuillier started with the able services of Alexander Daniell who had been a sub-assistant in Wroughton's party [IV, 397]. Daniell died in

[1] DDn. 659 (14), 14–2–57. [2] DDn. 21 (166–9), SG. to Mil. Dept., 14–3–62. [3] *GR. 1881–2* (61); *1882–3* ; *v.* DDn. 102 (150), Comm. report, 2–4–70; Svy. offices scattered in 5 buildings ; recd. all except MIO. to be under one roof ; discuss shift to Rānikhet rather than Mussoorie or Dehra, but greatly prefer retaining offices at Calcutta. [4] had resigned from Coast Ser. OTS. on death of his father [359]. [5] DDn. 663 (94), DSG. to SG., 30–3–57. [6] pr. to succeed Hoppner.

April 1855, and Hoppner was brought in from Vanrenen's field party to succeed him [349, 359]. The office then comprised besides Hoppner as Head Assistant, 1 accountant @ Rs. 100—1 writer @ Rs. 60—1 indexer @ Rs. 40—1 writer @ Rs. 25—3 writers @ Rs. 20 each.

DRAWING OFFICE, CALCUTTA

In 1844 the Drawing Office had John Graham as Head Draughtsman [IV, 445] —3 East-Indians, Joseph, MacVicars, and McReddie, on pay Rs. 70 to 150—and 10 Indians on pay from Rs. 16 to 60, "Miajan, Ainudin, Rahim Bakas, Golam Naki, Manirudin, Khadam Hoosen, Abdul Halim, Hosen Ali, Nasrat Hosen, and Zahur Ali". Of these Sheikh Abdul Halim was "first in order of merit" beside being an excellent litho-draughtsman [360].

Graham had been Head Draughtsman since 1827 and was promoted to Rs. 450 p.m., from 1853. As a younger man he had been specially skilled as map compiler, but as he grew older his work fell more to general supervision, and in later years he was much troubled by ill-health. He retired on pension in February 1858, and died in Calcutta five months later [IV, 445].

His post as Head Draughtsman was filled by William Scott, who was kept on with the field office at Dehra Dūn, and transferred to the Great Trigonometrical Survey in 1861. For charge at Calcutta John James was sent down from Robinson's party in the Punjab, where he had established himself not only as a first-class surveyor, but also as a hill draughtsman of outstanding ability ;

Mr. James is a most accomplished draftsman, well acquainted with the physical features of India, a thorough knowledge of which can only be acquired by experience in the field, and is not attainable by residents of cities. ... I consider Mr. James...pre-eminently qualified for the charge of the Drawing Office. ... Mr. James' salary as civil 2nd Assistant is Rs. 309–12–3, with equipment allowance of Rs. 60 per mensem. As the retention of these allowances will cause no increased expense, I propose that he should in Calcutta draw the same amount. ... The increased expense which living at the Presidency will entail...renders it indispensable that he should suffer no diminuation of receipts[1].

I doubt [Waugh writes to Depree two years later] whether they have got any field sketchers at home equal to our Mr. James. The originals of the survey he was engaged on are the best specimens of topographical drawing on the one-inch scale I ever saw [291][2].

From 1870, James was appointed Assistant Surveyor General in charge of map drawing and compilation, keeping the engraving and lithographic branches supplied with material. He took furlough in 1878 and on his return in 1883 was appointed Deputy Superintendent and given charge of a revenue survey party with recess quarters at Mussoorie. He retired on pension at the age of 55 at the end of 1884.

Charles Joseph had started as a draughtsman on the Madras surveys in 1823. He was transferred to Calcutta in 1835 and compiled many important maps there [III, 321 n.3, IV, 286–7]. Seeing no prospect of promotion, he resigned in 1845[3], getting the following "chit" from a Government Secretary ;

Mr. Joseph is well known to Thoby Prinsep [IV, 489] and myself, under whose superintendence he compiled the only good map extant of the country between Nagpoor and the Ganges in one direction, and Cuttack and Benares in the other. He showed great attention and skill in compiling this from a most heterogeneous mass of materials, and the result was... [a] remarkably full map of country till then quite unknown.

If you can forward his views in getting him a situation where his knowledge of outdoor engineering can be made available, and relieve his eyes from the fatigue of mapping in the Surveyor General's Office, you will do a great service to a very meritorious person[4].

For a time he was with P.W.D., and then Revenue Surveyor in the Sundarbans. He later compiled a *Map of the Grand Trunk Road* for the N.W.P. Government [315]. He died of cholera at Serampore on 4th June 1859, aged 58.

[1] DDn. 643 (210), SG. to Mil. Dept., 16–3–58. [2] DDn. 4 (61), 22–3–60. [3] DDn. 415 (6), Joseph to DSG., 17–3–45 ; DDn. 557 (100), SG. to DSG., 20–3–51. [4] DDn. 45 (7), from J. P. Grant, 13–1–45 ; John Peter Grant (1807–93) ; BCS., LG. Bengal, 1859–62.

Thuillier was far from satisfied with the quality of the drawing ;

For many months past I have been much dissatisfied with the state of the drawing department. ... Carelessness and inattention to business has been...commented on without any good effect, and...I...recommend the discharge of...four individuals...as a proper example[1].

In spite of punishments and rewards there was little improvement ;

What we most require are good compilers, men of education and professional knowledge who can be trained up to arrange...discordant materials, and exercise sound judgement...and a proper value on various authorities. ... They are required also to...superintend the native copyists, to examine their work, and thus render the...maps...as creditable as we could desire.

At present...Mr. Graham takes the general superintendence, leaving only two European assistants as compilers—Mr. Potenger on 120 rupees and Mr. Breum on 80 rupees per mensem. The former of these has been 10¼ years in the Department, and the latter 6 years. They have received but one small increase of salary during that period, the consequence of which has been the resignation of Mr. Breum. The strength is actually below...[that of] 1830, ... and no additions have been made to meet the extra calls...or the enormous access of...materials caused by the extension of 20 years survey, and the addition of large provinces [351–2]. ...

If...the scale of remuneration is not on a par with other departments, ... young men... seek their own advancement elsewhere. ... The European draftsmen, ... as soon as they have been taught and formed into useful assistants, have left the Department. ... Mr. Joseph preferred an appointment as Overseer in the Department of Public Works on some 145 rupees per mensem, and his loss has not yet been supplied. ...

Competent draftsmen and compilers cannot be found when wanted. They must be trained and formed for our purposes. ... The appointment of 4 or 6 European young men on a graduated scale of salaries as compilers and draftsmen, ... [with] some knowledge of the principles of surveying, seems to be most desirable, the salaries commencing at 50 or 60 rupees per mensem, to be raised to 80, 100, 120, and 150, according to merit. ... I am anxious to see the 3 draftsmen...on the contingent bill (...in force upwards of 20 years) [IV, 335] placed on the permanent list, wherein the lowest salary should be 20 rupees instead of 16 as at present[2].

After reference to the Directors in 1856 strength was increased to 5 East Indians on pay from 60 to 135, and 11 Indians from 16 to 55 rupees.

George Potenger retired on pension in November 1860, having "injured eyes and failing sight caused by the nature of the work". He had been "constantly ailing and subject to frequent...attacks of fever". Born in 1829 he had first joined the drawing office in March 1837—resigned in September 1841 to become Purser in H.E.I.C.'s steamer *Proserpine* on the China service—and returned to the drawing office in September 1845[3].

Vernieux was warned that he "must go on differently now, or I cannot retain him to spoil paper at his high salary ; this memo to be carefully filed"[4].

The Revenue Survey drawing office comprised nine Bengali draughtsmen under Walter Graham, who had been "brought up from early youth in the office under the auspices of his father"[5]. His untimely death in 1860 was a great loss.

COMPUTING OFFICE

When the Surveyor General went up country in 1844 he took with him Radhanath Sickdhar, his brother Srinath, Bholanath Mazumdar, and two others [341][6] leaving behind under De Penning Vincent Rees and four Bengalis [127][7].

On De Penning's death at the end of March 1845, only four months after Waugh's departure, Radhanath Sickdhar succeeded as Chief Computer but remained with the field office. The disadvantages of keeping so small a staff at Calcutta became evident when one man resigned in February 1848. Two of the others were required for the observatory and left the third idle for lack of a fourth with whom to compare computations [122][8]. At the end of 1848 permission was obtained to assemble the whole body of computers at Calcutta ;

[1] DDn. 472 (361), 1–2–48. [2] DDn. 555 (5), DSG. to SG., 24–7–51. [3] tension, DDn. 5 (113). 22–6–61. [4] DDn. 336, 20–1–59. [5] DDn. 624 (80), DSG. to SG., 5–4–56. [6] Shama Charan & Jai Narain Banerji. [7] Radhanath Sen, Gopinath Sen, Nanda Lal De, and Harkumar Mitra. [8] DDn. 459 (275–7), DSG. to SG. 4–12–48.

One half of the computing office remained with me in the field and the other half at my Calcutta office to bring up arrears. The work performed by the former portion has been in every respect satisfactory, but the labours of those in Calcutta have declined in consequence of the want of adequate supervision. ... A concentration of the entire computing office is urgently necessary for the sake of efficiency. ... Considering...the difficulty of recruiting in the Upper Provinces, ... I...recommend that the party now with me in the field should join the Presidency office whereby a monthly saving of Company's rupees 243–5–4...will be effected[1].

The Chief Computer and his party left Dehra at the end of January 1849, took boat at Gurmukhtesar on 12th February, and reached Calcutta early in May [128, 341, 372]. Waugh recommended Radhanath to Thuillier's care;

Every opportunity should be afforded him for the efficient performance of his work, and as he will now for the first time have the whole of...his office under his personal control, the entire responsibility of details will devolve upon him. ...

It will be necessary for me to maintain a direct correspondence...with the Chief Computer, and I hope this...will prove...not inconsistent with...your control...over the whole office[2].

Thuillier reported on 16th May that

The party have been located in the 3 rooms formerly occupied by Mr. De Penning, forming the entire west side of the upper floor of this house [351]. ... The Chief Computer has made every arrangement for the systematic despatch of business, and will carry out the details of his office in direct communication with yourself. ... I have already found in Baboo Radhanath Sickdhar a...willingness to accommodate which is very pleasing[3].

Replacements had to be made when trained computers were tempted away by offers of higher pay but there was never any difficulty in finding new men, who had of course to be trained from the start [IV, 340–1].

By 1855 the output of the trigonometrical survey had increased to such an extent that the computing office could no longer keep pace. Waugh's proposals for improving the terms of service were not accepted;

The Hon'ble the President in Council strongly objects to the principle of increase of pay according to length of service, and requests that the Surveyor General will recast his scheme ...suggesting a graduated scale of permanent pay, and stating whether all that is necessary may not be effected by the simple addition of some computers and writers[4].

In revising his recommendations Waugh again stressed the fact that

a ready-made computer...is not procurable in India. ... A strong motive is required to incite a person to acquire these qualifications. ... Supposing a person by working at the computing office for 6 years has acquired the necessary qualifications of an efficient computer, it will be in the interest of Government to accord him such a salary as would induce him to remain in the office, for in the event of his retiring all the expense incurred in his training would be lost. ...

Nothing short of the graduated scheme originally submitted will be found to answer.

He put up two alternative schemes, Rs. 1,189 and 1,329 p.m. including pay of the Chief Computer @ Rs. 400 p.m. Government approved the lower of the two, less Rs. 105 p.m., which gave an increase of Rs. 313 over the existing scale[5].

In 1856 Radhanath made a full report of the work of the Computing Office from the time it had been concentrated at Calcutta [128];

At that time the office consisted of 1 Chief Computer—1 Head Native Computer—1 Deputy Native Computer—6 Assistant Computers. The office...remained upon this footing till within the last five months, when orders were received...for reorganizing the same. ...

In the year 1851 the printed *Tables...for India* were computed [122–3]. ... Most useful in the calculation of the Tables...were Baboo Sreenath Siedar and Radhanath Sen. ...

Seeing that the...business has greatly increased of late, the Surveyor General recently laid before Government a scale of progressionally increasing remunerations...to a computer as he improved in efficiency, his maximum pay being fixed at Co.'s Rs. 60 per month. I...regret that this arrangement was not at once sanctioned, ... as it would have made the Computing Office as efficient as could be desired. ...

The computers generally have given great satisfaction. ... Those who have made themselves most useful, and who can...be entrusted with independent computations, are...Baboo Sreenath Siedar—Radhanath Sen—Joynarain Banerji—Bholanath Mozoomdar[6].

[1] DDn. 468 (134–7), SG. to Mil. Dept., 13–11–48. [2] DDn. 561 (12), SG. to DSG., 13–3–49; Shibnarain Datt & Kedarnath Sen joined 16–5–49. [3] DDn. 480 (73–4). [4] DDn. 547 (298), from SG. 14–1–55; 671 (58), from Mil. Dept., 30–6–55. [5] DDn. 547 (396), from SG., 28–8–55; 671 (74), from Mil. Dept., 17–11–55. [6] DDn. 662 (141), Ch. Compr. to DSG., 3–4–56.

In October 1861, after Waugh's retirement and after Radhanath Sickdhar had expressed his wish to retire, the Superintendent Trigonometrical Surveys, James Walker, asked for the transfer of the Computing office to Dehra Dūn. "Much inconvenience and delay has been caused by the separation of the Computing Office from the Trigonometrical Survey [344]".

He had already two houses at Dehra for the trigonometrical survey offices, and it would be easy to arrange for a third for the Computing Office. The move was authorised, and effected during 1862[1] [341 n.2]. The establishment then stood at 1 Chief Computer—1 Deputy—1 Senior Examiner—8 junior Computers—4 writers. Radhanath Sickdhar retired on pension from 16th March 1862 ; his brother Srinath had already resigned on account of "incipient cataract of both eyes". Bholanath Mauzamdar was the only one of the Calcutta establishment to move up country, to become Chief Computer ; the remainder preferred to resign. Computers were henceforward recruited from up-country sources [344].

CALCUTTA OBSERVATORY

The Survey Observatory had been first erected on the proposal of Valentine Blacker on the roof of the office at No. 35/37 Park Street [III, 187–8]. After the move to No. 21 Chowringhee a small building was specially erected in the grounds of that office [IV, 332]. Observations for the daily time signal and for meteorological purposes were under charge of Vincent Rees who had the assistance of one of the computers [IV, 114–5, 119–20, 462 ; V, 139].

In 1848, Rees pointed out that the Chowringhee building was most unsuitable as it gave little room for the instruments, and none whatever for an observer to sleep in. It was completely dominated by surrounding buildings[2]. When the office moved to Park Street the following year Blacker's observatory was re-erected with a new dome [351]. As Rees was now granted six month's sick leave to Mauritius it was arranged that the Chief Computer, who now had living quarters in the new building, should give up an hour for the observatory duties, making up time on his computations out of hours. Gopinath Sen was the regular observatory assistant [354 n.7][3].

In his instructions for the re-erection of the observatory the Surveyor General pointed out that corresponding observations were no longer needed since the field surveyors now made connection to points of the G.T.S., but that the "shewing mean time is the special business of this observatory"[4].

> It has been the practice for some years that one or two computers should daily attend on Mr. Rees at the observatory to assist in shewing Mean Time. This duty...causes considerable interruption to the...computations. ... Every endeavour should be made to reduce the time they are absent at the observatory[5].

Rees returned from leave and resumed charge during February 1850. He was much handicapped by chronic *chorea*, and from 1843 had been "as deaf as an adder". In 1852 he retired after 27 years work connected with the observatory.

The Chief Computer again took charge[6], and the meteorological observations were brought into line with the new rules [139–40]. From the savings on Rees' salary four extra assistants were engaged, on Rs. 20 to 30 each, being additional to the computer responsible for the daily signal to Fort William [IV, 114–5] ;

> At exactly five minutes before mean noon a ball is hoisted up on a mast at the Observatory, seeing which the signallers at the Fort semaphore tower, a distance of a mile and a half, raise a ball on an iron crane fitted up for the purpose. ... The mean noon shewn is that for the Semaphore Tower. To this end, at 1½ seconds before that time the observatory ball is dropped by a classie letting go a rope ; observing which the signallers let fall the semaphore ball likewise, and in a similar manner, which event ought to occur at the time of the Mean Noon. ...

[1] DDn. 7 (115), from Mil. Dept., 26–3–62. [2] DDn. 479 (4), Rees to DSG., 23–5–48 ; 472 (453), DSG. to SG., 26–5–48. [3] DDn. 474 (151), from DSG., 27–7–49 ; 561 (59), from SG., 6–8–49. [4] DDn. 474 (245), reply to Ch. Compr.'s note of 29–12–49. [5] DDn. 561 (12), SG. to DSG. 13–3–49. [6] with allce. Rs. 200 p.m.

A powerful telescope is put up at the Observatory, with which the dropping of the Semaphore ball is watched and the time of its occurrence is noted. ... There will generally be some error...which is always noted...at the Surveyor General's office. ... When the error...exceeds half a second it is published in all the...daily papers as well as in the Calcutta Gazette. Likewise a notice...is put up at the Bankshall. The Mean Noon every day is determined by a meridional observation of the Sun, and for making such observations a 2½ feet transit telescope by Dollond is forthcoming at the...observatory [138–9][1].

From 25th June 1858 signals were made by electric cable which gave a great deal of trouble to begin with [140–1]. The time of the signal was also changed to one o'clock, and deduced from the transit observation "immediately preceding".

The time ball...used...with the electric wire is not the old ball, ... which...was scarcely visible to the whole shipping. The ball now adopted is one of much larger dimensions. ... The electrical wire connecting the Observatory with the Semaphore Tower is laid underground. ... The battery used at the observatory consists of twenty cells[2].

LITHOGRAPHIC PRESS

The Lithographic Press was installed at the Surveyor General's office in March 1852 by the transfer from the Government Press of two hand presses and their crew and two litho-draughtsmen. "My first care" writes Thuillier,

was to secure the services of a competent Superintendent, combining the qualities of a good draftsman with a knowledge of transfer drawing and litho. business generally. Mr. H. M. Smith, at that time attached to the Quartermaster General's Department[3] who was well known to me...from his experience in lithographing the series of N.W.P. district maps published under...my predecessor [312–3], was the only man in Calcutta fit for the situation. ... He was allowed by the Quartermaster General....to accept the appointment[4],

and joined on 17th April. Two European assistants were also engaged, De Hone and Musgrove, besides an engraver-draughtsman Namiruddin [332 n.5]. An establishment of draughtsmen, printers, and spongemen brought the monthly pay roll to Rs. 720. During 1854–5, this staff was called on to work at high pitch on the printing of the postage stamps under most difficult climatic conditions. Extra presses were installed and establishment raised to Rs. 1,060. During 1855 an experienced printer, George Stapleton, was further brought in from the Government Press on Rs. 250 p.m. [IV, 335–6, 350 ; V, 332–5, 360].

Smith was born about 1806 "son of John Jacob Smith, a buccaneer who captured Saugor Island at the mouth of the Hugli". The son found employment in the lithographic press under Dr. Rind [III, 298]. He was not only a high-class draughtsman who actually designed the postage stamps, but also a first-class technical manager who did magnificent work in the reproduction of maps. In 1865 he was granted a good service pension on Rs. 225 p.m., "after serving Government for 43 years continuously". Pending the arrival of a new Manager from England his services were retained up till 15th April[5].

MATHEMATICAL INSTRUMENTS

Saiyad Mir Mohsin Husain, who had won Everest's complete confidence by his skill in repair and construction of scientific instruments, had been formally appointed Mathematical Instrument Maker under the Directors' letter of 26th September 1843 [IV, 125, 458]. Though unable to write English, he was able to conduct his business to the entire satisfaction of both Waugh as Surveyor General and Thuillier as Superintendent of the Mathematical Instrument Department. He held office right up to the time of his death which occurred on 11th February 1864. "Ever at his post, his whole life seems wrapped up in the duties of his profession"[6].

[1] DDn. 669 (13), from Ch. Compr., 3–4–56. [2] DDn. 664 (209), from Ch. Compr. from, 27–7–58. [3] under which the Govt. Press was managed. [4] DDn. 562 (220), DSG. to Home Dept., 25–3–52. [5] Govt. GO., 18–7–65 ; *GR Topo., 1864–5* (41). [6] DDn. 661 (49), DSG. to Mil. Bd., 15–3–55.

Mohsin Husain had been employed with the Surveyor General up country till Everest's departure, when he took over charge of the Calcutta workshop, first under Henry Goodwyn and then under Wroughton as Deputy Surveyor General [162, 164]. The workshop had now to be entirely reorganized, and an artillery bombadier was appointed Assistant Mathematical Instrument Maker. "It was a piece of good fortune that a workman of Mr. Cribble's skill and training was...found to fill the situation, and who...was content to receive at starting a staff salary of 50 rupees in addition to his military pay and allowances".

Cribble was a great success and helped considerably in the construction of the two 24-inch theodolites made up in Calcutta [152–3]. In 1849 he took his discharge from the army with the rank of sergeant, and pressed for increase of survey salary to Rs. 100, which had been promised when he first joined in 1844. The Surveyor General strongly supported him. "It would not be possible to replace him by any workman of equally moderate expectations. ... I...recommend...that Government...augment this deserving individual's salary to Co.'s Rs. 150" bringing supervision charges to Rs. 500—Mohsin Husain Rs. 250, Cribble 150, Thuillier100—as against pay and allowances drawn by Barrow, Rs. 700 [IV, 122][1]. Cribble's salary was, however, only raised to Rs. 100. On his transfer to Roorkee, his place was filled by Edward Stapleton as clerk @ Rs. 80, and Saiyad Ismail, Mohsin Husain's son, as storekeeper @ Rs. 50.

In 1853 Thuillier pressed for an increase to Mohsin Husain's salary ;

The Mathematical Instrument Department...has been put on a new footing, and made the general depot for...all instruments below Allahabad. Owing to a parsimonious policy on the part of the Military Board, the increasing duties and responsibility for...such an extent of Government property have been met merely by the abolition of the Assistant in the manufacturing department. Mr. Cribble was transferred to Roorkee in January last, and the whole of the supervision rests on the Meer Sahib. ... The arrangements now in force...having the workshops in close connection with the Surveyor General's Office, as well as the Lithographic Press, are admirably adapted to ensure proper control...on my part, and by the whole of the...stores connected with our profession being under the Instrument Maker's care. ...

Said Mohsin has now served close upon 30 years. ... Having been on his present salary for about eleven years, a personal allowance...would be very gratifying to this worthy old gentleman. ... A recommendation was made in my annual report to the Military Board for 1850–51, for an increase of 100 rupees, ... but the Board...whilst highly commending his zeal and work, expressed regret that they could not then comply with my request[2].

He further asked for an increase to the establishment of workmen, the present number being only 22 on the permanent list and 70 on contingent charge ;

The permanent establishment...has not been altered for very many years, but it is totally inadequate. ... The present total strength amounts to 92, ... and it is this...contingent establishment which I am desirous of increasing temporarily for...adding...a few of the more useful instruments, ... which...can be so infinitely better constructed here, to suit wants of surveyors and withstand the effects of our Indian climate, than in England[3].

On a reference to London the Directors approved a personal allowance which raised Mohsin Husain's salary to Rs. 400 p.m. During his deputation to Karāchi [44, 158] he was allowed an extra one-third salary, though there was some argument as to whether it could be drawn on the personal allowance[4]. During his absence Said Ishmael, the storekeeper and assistant to his father, was entrusted with the supervision of the workshops with an increase of salary...50 rupees per mensem. ... The entire...manufacturing and repairing branches have now been executed for a period of six months by Syud Ishmael, who...has proved himself a most valuable...supervisor[5].

Saiyad Ismail had received a good English education at St. Paul's School, Calcutta, and had in 1850 been appointed computer at Revenue Survey headquarters. On his father's death in 1864 he officiated as Mathematical Instrument Maker on salary Rs. 250, until an English mechanic was appointed from Thomas Cooke's establishment at York.

[1] DDn. 462 (364–6), SG. to Mil. Dept., 4–12–49. [2] DDn. 593 (391,), DSG.'s Report, 6–7–53. [3] DDn. 563 (112), DSG. to Mil. Bd., 30–8–53. [4] OD. to B., 14–10–54 ; DDn. 551 (259), Mil. Dept.. to MAG., 16–11–55. [5] DDn. 061 (4), 15–3–55.

CLERKS

Name, Birth, Death	Appointed	Employment	Domestic
BARNES, Geo. [IV, 349] b. *c.* 6-11-1799.	1-7-36	wr. C-in-C.'s office, 10-7-35 ; SGO. Calcutta, 1-7-36 ; ret. on pension, 27-8-55.	
BLEWITT, Francis Colwell [418] b. *c.* 1-1-28.	1-8-43	wr. SGO., Calcutta ; with fd. office to Allbd. Oct. 1844 ; tr. to GTS. 29-3-45.	
CUNNINGHAM, Alex Chas. [352] b. Bombay, *c.*, 30-10-33 d. Calcutta 24-10-86.	GTS. 1-9-52	from GTS. to DO. Calcutta, Sept. 1853 ; wr. SGO. 1-12-55 ; Hd. Wr., 27-3-57 ; HA. Rev. Svy. hdqrs., 1-4-62 till pension. 17-7-86.	Son of Alex. *c.* (1803-53), Ship's Capt., d., Calcutta, 15-9-53, and Maria his wife.
DANIELL, Alex. [IV, 397] b. India, 1812-3 d. Calcutta 19-4-55.	1844	Rev. Svy. NWP. 1834-42 ; Hd. Dmn. Rev. Svy., Calcutta from 1844 ; HA. Rev. Svy., Calcutta 1848 till death.	Son of David and Jane.
DUHAN, Harry Reilly b. *c.* 9-1-27.	22-4-45	wr. S.G.'s fd. office. Allbd. & DDn. ; Hd. Wr. & actg. Regtr., 17-11-50 ; extra Civ. Asst. & PA. to SG. 27-3-57 ; PA. to STS., 12-3-61 ; pension as Survr. 1st gr. & PA. to SG. 1-4-83.	son of Wm. Duhan who d. Cawnpore, 28-11-50 aged 58. m., Mussoorie, 10-2-58, Julia Mary, aged 14, dau. of John Taylor.
FRANCIS, M. d. 16-11-92.	1854	Wr. SGO., ret. as Hd. Clerk, 1-11-92.	
HOPPNER, Edw. Wm. [IV, 399 ; V, 441].	9-6-56	from Rev. Svy. NWP. to HA. Rev. Svy. Hdqrs. Calcutta, till *c.* 1-4-62.	m. before 1860 ; pr. kin to Rev. ... Hoppner of Patna.
MACKAY, J.	1855	wr. Rev. Svy. Hdqrs. ; still serving 1870.	m. before 1860.
O'BRIEN, M.	1860	wr. Rev. Svy. Hdqrs.	
OLLIVER, Andrew Cornelius [IV, 350, 385] b. Hdbd., 30-4-22 d. DDn., 24-8-56	1-11-44	from GTS. appd. Hd. Wr. SG.'s fd. office Allbd. & DDn. till death.	son of Joseph O. [III, 491]. m., Landour 18-8-43, Emilie Martha Billon, pr. dau. of Emile, B. [439].
SCOTT, Robt. b. *c.* 22-1-22 d. DDn., 12-9-74, unm.	25-10-44	wr. SG.'s fd. office ; SAS. & Storekeeper 1-5-53 ; Asst. Survr. from 1871.	bro. to Wm. Henry [360].
STAPLETON, Chas. Thos [IV, 350] b. Nov. 1819. d. Calcutta, 12-10-61.	1850	writer, Rev. Svy. Hdqrs., Calcutta.	pr. kin, to Edward [360], and Geo. [IV, 335].
WEBB, Geo. Parker [IV, 350]	July 1834	Biographical Notes.	

DRAUGHTSMEN

BOLST, Wm. Chapman b. 22-9-25, d. DDn., 2-9-53 ; MI.	16-11-48	dmn. Calcutta DO. ; tr. to SG's fd. office, DDn. 1850.	pr. son of Wm. Henry & Mary, of Calcutta, & bro. to Geo. Chapman [439] & Herbert James [430].
BONNAUD, Geo. Alfred b. *c.* 5-11-42.	21-11-59	appce. dmn. Calcutta ; disch., 30-11-61.	
BREUM, Christian b. 27-12-14.	13-6-45	dmn. Calcutta DO. ; resd. 1851.	arrd. India Nov. 1843.
CHILL, Thos. Potenger b. *c.* 20-8-31 (32?).	1-9-52	to SAS. GTS., for topo. Punjab, dmn. Calcutta 9-10-53 ; to ML Dept., 1-9-59.	m. before 1859 ; pr. kin to Wm. Richd. [IV, 386 : V, 440].
CORNELIUS, John [IV, 350] d., DDn. 15-5-79, aged 80. MI.	1-10-31	from Nāgpur Svy. to Calcutta DO. ; SG's fd. DO., 1844 till ret. Nov. 1852.	m. 1st., DDn., 5-3-40, Charlotte Watson, wid. ; 2nd ; Julia Matilda ; father of Walter John (1849-1931), appd. Topo. Svy. 1866.
GRAHAM, John [IV, 445] b. India, *c.* 7-12-01 d. Calcutta, 10-7-58.	1816	appce. topo. survr. ; Hd. Dmn. Calcutta DO., Aug. 1828 ; ret. 1-6-58.	m. 4 times [IV, 445] ; 1st., 6-1-20 ; father of Walter [*inf.*].
GRAHAM, Walter Rose Malcolm b. 1821, d., Calcutta, 15-11-60.	1844	dmn. Rev. Svy. hdqrs. ; Ch. Dmn. 1850(?) till death.	son of John [*sup.*].
JAMES, John Owen Nix (1820-1900)	1-9-58	ch. Calcutta DO. from Topo. (431).	
JOSEPH, Chas. [III, 321 n.3 ; IV, 350] b. *c.* 1-8-02, d. Serampore, 4-6-59.	1-5-23	dmn. SGO. Madras ; to SGO. Calcutta, 1835 ; ret. 1845 ; Supervisor PWD. Benares Rd., 2-7-45 ; Rev. Survr. Sundarbans, 1854.	his dau. m., Calcutta, 1855, Mark Edwin son of Joseph Olliver [III, 491].
LIVESAY, C. E.	1858	appce. Calcutta DO. ; not in 1859 list.	
MCREDDIE, Geo. King [III, 314 ; b. 20-2-05. IV, 350]	24-11-24	dmn. Calcutta DO. ; not 1847 list.	
MACVICARS, Wm. [IV, 350] b. Madras, 22-6-05. d. Calcutta, 1848/9.	1831	from QMG. Madras ; dmn. SGO. Madras, 1831-3 ; Calcutta ; DO. ; from 1835 till death.	
NAMEY, J. P. b. *c.* 3-6-39.	1-11-55	Calcutta DO. ; drawing Rs. 150, Feb. 1866.	
POTENGER, Geo. [IV, 350] b. *c.* 12-1-21.	1-3-37	dmn. Calcutta DO. ; resd. 2-9-41 [354] ; re-appd., 8-9-45 ; pension 1-12-60 under GO., 23-5-61.	
POULSON, J. H.	Jan. 1856	dmn. Calcutta DO. ; with Rev. Svy. hdqrs., 1862 ; compiler @ Rs. 200, 1866.	
SCOTT, Wm. Henry [III. 314 IV, 350] b. Sept. 1812, d. DDn., 10-2-73, MI.	1-3-27	dmn. Calcutta DO. ; to SG.'s fd. office, 1833 ; Ch. Dmn. fd. office, DDn., 1-6-58 ; Ch. Dmn. with STS., Feb. 1861 ; Civ. Asst. 1st gr., 1-4-66, till death.	son of Wm. Scott [III, 501], and bro. to Robt. (*sup.*) ; m., Landour, 30-9-43, Clarentine Eleanor Shorts, aged 14.
SIRET, John	1847/8	Calcutta DO. ; resd. 15-1-51 after 3 y. service.	
VAILLANT, J.	1856	appce. dmn. Calcutta DO., ; resd. 14-4-59.	kin to John Pearson V., whose son Chas. Louis m., 14-12-67, Matilda Gleeson.
VERNIEUX, Lawrence Prudence b. 24-11-14.	14-9-52	Collr.'s Office, Hooghly, 1833-9 ; Librarian & Drg. mr. Hooghly Coll., 1840-9 ; Record Keeper, AG.'s Office, 1-3-51 ; dmn. Calcutta DO. 14-9-52 ; serving 1866.	

INDIAN DRAUGHTSMEN

Abdus Sobhan, 1854–66.
Ain-ud-din, 1844.
Ghulam Khadar, 1854–60, DDn.
Ghulam Naki, 1844–66.
Ghulam Akbar, 1854–66.
Husain Ali, 1844–66.
Jai Narain Biswas; Hd. Dmn. Rev. Svy. Hdqrs.
Khadam Husain, 1844.
Manir-ud-din, 1844–61.
Kallin-ud-din, 1854–60, DDn.
Miajan, 1844–59; d. Feb. 1859.
Nasrat Husain, 1844.
Nabi Baksh, 1856–60.
Najib-ullah 1856–60, DDn.
Rahim Baksh, 1844; DDn. 1849, 6mo. d. 26–11–53.
Sheikh, Abdul Halim 1844–55 from 1859; Litho branch [*inf*].
Sheikh Abdul Khadar, 1832–60; d. DDn., 17–7–60.

COMPUTERS

Name, Birth, Death	Appointed Calcutta	Appointed DDn.	Service
Bholanath Mauzamdar	1840	...	fd. office, 1844–9; Calcutta, 1849–51: Asst. Overseer, PWD., 1851–2 re-appd. Compr., 1852; junr exmnr., 1855; Dep. Compr. 1–2–62, on tr. to DDn.; Ch. Compr., 1862; pension from 1865
Chedama	...	1857	fd. office 1857–60; 1 DDn. Comp. Party, 1–1–61.
Chitur Mal	...	1857	fd. office 1857–60; DDn. Comp. Party, 1–1–61.
Ganga Prasad	...	1857	fd. office 1857–60,; DDn. Comp. Party. 1–1–61; Ch. Compr. 1865–90.
Gopal Chandra Gupta b. *c.* July 1830.	4–4–51	...	resd. before 1860
Gopinath Sen b. *c.* 8–10–21.	28–1–41		from office Civil Auditor, Metl. Compr. SGO. Obsy., 4–4–53; Supt. Obsy., 16–3–62; still serving 1866.
Haru Kumar Mitra b. *c.* 1823.	21–6–44		still serving 1851.
Isan Chandra Bose	1845		fd. office.
Jai Narain Banerji b. *c.* 1821.	10–3–44		fd. office Oct. 1844–Jan. 1849; Calcutta from 1849 junr. exmnr. 1855; resd., 6–4–62.
Kedarnath Sen	16–5–49		resd. to be Asst. Overseer PWD., 1851.
Nanda Lal De	1844		resd. Feb. 1848.
Panch Kuri Gupta b. *c.* Aug. 1827.	4–4–51		from Calcutta Mint; resd. 17–6–60.
Parsid Narain Sebastian	1845		with fd. office 1845–7.
Radhanath Sen b. *c.* Aug. 1817.	27–3–38		Dep. Native Compr. Calcutta, 10–5–44 til May 1849; senr. exmnr. 1855; Metl. Compr. SGO. Obsy. from 1862; Hd. Clerk, Rev. Svy. hdqrs,. from 1865.
Radhanath Sickdhar			*v.* Biographical Notes.
Shama Charan Bose	1840		fd. office Oct. 1844; pr. resd, 1845.
Shib Narain Datt b. *c.* June 1828.	16–5–49		resd. before 1860.
Srinath Ancharia	July 1856		resd. Calcutta 6–4–62.
Srinath Sickdhar b. *c.* Dec. 1816; bro. to Radhanath.	25–1–38		Dep. Compr. 10–3–38; Hd. Native Compr., 19–6–38; fd. Office Oct. 1844–Jan. 1849; Calcutta, May 1849 till resd., 7–1–62.

LITHOGRAPHIC PRESS

ADRO, G. W.	...		Press asst. 1860.
DE HONE, G. W.	1852		Press asst.; not in list of 1860.
MUSGROVE, J.	1852		from dmn. Rev. Svy., to Litho. Dmn.; serving 1878–9.
Sheikh Abdul Halim	...		Litho dmn. 1859, from dmn. SGO (*sup.*).
SMITH, Henry Mariano [357] b. *c.* 1806.	...	17–4–52	Govt. Litho. Press, Calcutta, dmn. 1828–52; Hd. Dmn. SGO. Litho Press, 17–4–52 till ret. 16–7–65.
STAPLETON, GEO. H. [IV, 350].	...	1855	from Govt. Litho Press.

MATHEMATICAL INSTRUMENT DEPARTMENT

CRIBBLE, H. J. ... b. St. Mary's Huntingdon, 1812/13 arrd. India, 1838.	1844	Enlisted Ben. Art. London, 1838 sailing for Bengal, Aug., purch. disch. Feb. 1850; appd. Asst. Math. Inst. Maker; 1844 tr. to Thomason Eng. Coll. 21–1–53; pr. identical or kin "Mr. Cribble", Supt. Elec. Tel. Workshops, Calcutta 1859.
ISMAIL, Saiyad ... ... only son of Mohsin Husain [*inf.*]	1853	1850–3 Compr. Rev. Svy. Hdqrs; Asst. Math. Inst. Maker; offg. Math. Inst. Maker, Feb. 1864; serving as Asst. 1875.
MOHSIN HUSAIN, Saiyad Mir [IV, 458] b. Arcot, Madras, d. Calcutta, 11–2–64.	1824	Inst. Repairer, SGO., Calcutta; SAS. GTS., 3–10–36; Math. Inst. Maker, 26–9–43 till death.
STAPLETON, Edward ...	1853	pr. kin to Chas. Thos. [359] and Geo. H. [IV, 350, *sup*].

CHAPTER XXIII

FIELD UNITS

FIELD PARTIES ; *Trigonometrical — Topographical — Revenue — Field Season— Recess Quarters* — TRANSPORT — *Boats — Elephants — Railways* — ALLOWANCES — GUARDS & ESCORTS.

WHEN Waugh took over charge there were, besides the Bombay party, six parties of the Great Trigonometrical Survey working in Bengal—Karara, under Shortrede, recess quarters at Allahābād—Gora, under James, Chunār—Chendwar, under Logan, Allahābād—North Connecting, under Du Vernet, Dehra Dūn—North Maluncha, under Renny, Allahābād—Calcutta Meridional, under Lane, Berhampore. As work progressed these parties were shifted from one series of triangles to another, whilst officers came and went[1].

Karara :—Shortrede, 1841–5 ; from 1845 under Hill to South Maluncha and East Coast.

Gora :—James, 1843–4 ; Garforth, 1844–7 ; under Armstrong, 1847–8, to N.E. Longitudinal ; 1848–52, Hurilaong ; Oct. 1852 to Jogi-Tila, Punjab ; 1856, under James Walker to Gt. Indus.

Chendwār :—Logan, 1843–6 ; to N.E. Longl. 1846–50 ; as 2nd Hill Series completed N.W. Himālaya Series to Peshāwar 1850–2 ; on Rahun Meridional from October 1852.

North Maluncha :—Renny & Clarkson, 1843–5 ; Reginald Walker, 1845–7, to N.E. Longl. ; Lane to Sikkim 1847–8 ; Renny & Strange, as Great Longl. Sironj to Karāchi, 1848–53 ; Tennant to Great Indus, 1854–6 and Jogi-Tila, 1856–7.

Himālayan, North Connecting :—Du Vernet, 1841–4 ; Karara, 1844–5 ; Gurwāni, 1845–7 ; N.W. Himālaya, 1847–52 ; Mulheran, 1853–5 ; Montgomerie, Kashmir from March 1855.

Calcutta Meridional :—Lane & Peyton, 1843–8 ; Peyton & Nicolson, N.E. Longl. 1848–50 ; Nicolson, 1850–2, N. Parasnāth ; Nicolson & Du Vernet, from 1852–3, Assam Longl.

When Hill took over the Karara party for his move to the East Coast, he was given the following instructions ;

The native establishment...is the same as that hitherto employed on the Karara Series and, as it contains a considerable proportion of trained men, well-skilled in the various duties of the Department, you will...commence work under circumstances particularly favourable. ...

You will...draw up monthly a nominal roll of this establishment which will accompany your pay abstract when sent to the Pay Office. The...monthly expense incurred...is on no account to exceed that authorised by Government, viz., Co.'s rupees 491, ... the single case excepted wherein the Native Doctor, from length of service, becomes increased from 25 to 30 Co.'s rupees. You will only give the highest rates of pay to men who deserve that indulgence, and...carry any balance which may arise to the credit of Government [453]. ...

The sum of 44 Rs. per month is allowed you for baggage tents...reserved entirely for the public use, "... shelter for the instruments, guard, and native establishment. This is of the nature of a contract, ... a certificate to which effect will accompany your abstracts. ...

There is sent with you an observatory tent, ... the property of the State, ... repaired, renovated, and carried at the public expense. ... In addition...you will receive...an Office Tent, ...which is Government property, ... and which is...to enable you and the sub-assistants...to carry on computations in the field, and to afford shelter to the public stationery and records.

To Garforth on the Gora series he writes ;

It is a standing rule...that public office should be held daily, Sundays excepted, and it is for this purpose that the State incurs the expense of keeping up an office tent for...each series. The usual hours of business when the party marches daily are from 11 A.M. to 3 P.M., but if there be any pressure of office work the time may be extended [III, 256 ; IV, 338]. ...

The officer-in-charge...has always been expected to sit with his Assistants and superintend their proceedings. I desire that no innovation be made on this good old rule, and that you

[1] 3 civ. assts. to each party ; raised to 4 from 1847 [403].

will...understand that I consider the contrary system of segregating oneself from public office to be very prejudicial to good order and efficiency. The effect of it upon your own party in the short space of 12 months has not failed to attract my attention[1].

The Surveyor General's scrutiny of contingent charges was no mere formality. He asked Strange on the Great Longitudinal series

why 12 extra men should be employed in carrying up the observatory tent and assisting the carriage of the instrument up the hill. If a small party of coolies, say 20 or 30, ... were employed in advance...in preparing roads, there would...be few cases in which the cattle could not ascend the hill tops, or at any rate very nearly to the top. I have sometimes had to make roads 5 or 6 miles long in very rugged mountains and in all sorts of geological formations, from granite and basalt to sandstone disposed in mural precision. A smart gang of workmen might make all the roads in 2 or 3 months, and...no extra aid...would be wanted [38–9][2].

The several trigonometrical parties were now working under widely diverse conditions, and successful progress depended largely on the character of the officer in charge. Renny, Logan, Montgomerie, and James Walker write very little of their difficulties, but Strange made the most of them, and the letters that passed between him and the Surveyor General went to fantastic lengths, first through the wilds of Rājputāna and later through the forest-clad hills of the East Coast country [345].

Lane, who had been with Strange to Karāchi, found progress up the Assam valley so fraught with difficulties that the Surveyor General was led to abandon the enterprise, and turn operations to easier country across the Khāsi plateau [31–2].

The formidable difficulties are [writes Lane] First, russud[3] for the party, and Second, ... carriage, ... together with coolies or labourers for...various duties. ...

In reference to russud, ... markets are held in certain villages in the...plains only...on different days of the week, but...these hauts are few and wide apart, and...the supply so procurable at a time will suffice but for one or two days consumption. ... The produce...is brought together in small quantities...from neighbouring villages...solely to meet the ordinary wants of the people themselves. ... There is not the smallest chance of ever procuring the least russud from the miserable hamlets widely scattered over the interior of the hilly tract.

It will...be...necessary to adopt the course...of obtaining...the greater portion of the provisions for the party from Gowhatty and from Nowgong, and stowing it at particular posts... from whence to provide the different stations as required. ... I...suggest...that supplies...be in the first instance carried about in boats which could be charged for in the contingent bills, ... and from these be transported by the elephants...to...convenient destinations along the bases of the Cossia and Jynteea, and Mekir and Rengmah Naga plateaux, and from such posts be conveyed into the interior of the hills by tattoos and coolies. ...

I...append an estimate of...the least number of tattoos and coolies required, ... the latter on regular wages throughout the field season, with the additional expense of a month to come from, and another month to return to, their homes in...Hazaribaugh. ... Where tattoos can be employed...it will be best to resort to their use, and...Dangars from Hazaribaugh...would doubtless be the best adapted for coolie work and would at five rupees each be as cheap as practicable for Assam [454 n.3]. ...

Considering the extraordinary difficulties of the Province, and the prohibition of the Lieutenant Governor in regard to russud and coolies, with the consequent utter inability of the... local authorities to afford the slightest assistance, even in the most populous and richest portions of the districts, ... I do not see how the Series can progress. ...

The very high expense attendant on a marching life in Assam was long since submitted to your notice. The extra wear and tear of camp equipage and the high wages to servants—the hardships and privations—the extraordinary sickness and the mortality—are also greater on this than in any other party. The number of Assistants who have...seceded...owing to the enormous expense and to sickness...is too well known [461–2]. ... Every article of consumption is exorbitantly high priced...whilst all our English supplies...have been obtained from Calcutta by boats and by dak bhangy [III, 518] at a high additional cost, and must continue to be similarly procured at still greater expense as the Series progresses[4].

Lane asked for extra expenditure and allowances that amounted to at least Rs. 1,123 a month, which Government declined to meet. Further progress up the Assam valley was thereupon suspended [32][5].

[1] DDn. 491 (247–60), 12–9–45. [2] DDn. 616 (106), 7–10–50 [para 19]. [3] food supply. [4] DDn. 702 (73), 9–6–59. [5] DDn. 642 (348), Mil. Dept. to SG., 9–11–59.

At the end of 1843 there was only one topographical party at work, the Hyderābād Survey under Henry Morland, but during 1844 the survey of the hill areas of Ganjam was restarted under Halpin, and after his death in 1848 carried on under Robert Howard until Saxton took over in 1850. From 1844 to 1852 Ouchterlony carried out a combined revenue and topographical survey in the Nilgiri Hills with a small party of Madras assistants [179–80, 421].

When Morland dropped out on attaining his regimental majority, the Hyderābād party was taken over by Major John Brown who had no previous survey experience [384]. Owing to local disturbances and Brown's lack of control the survey was closed down in 1850 and the assistants transferred to the Ganjam party. During 1855, work was re-started in Berār under James Mulheran who had proved himself on topographical work in the Himālayas [178, 416].

This Himālaya survey had been started by Du Vernet's triangulation party which was in 1850 switched to topographical work when Logan's party took over the North-West Longitudinal series. Du Vernet himself was the only member of the party with any previous topographical experience. On his transfer to Assam the Himālaya party was taken over by Mulheran and on his move to Berār passed to the charge of Montgomerie for the survey of Kashmir [200–8, 361].

Following the occupation of the Punjab in 1846 two local surveys had been put in hand on the North-West frontier. A survey of Peshāwar District was carried out by James Walker and another of Hazāra by Robinson, both being undertaken under the orders of the local administration. Both officers were in due course transferred to the orders of the Surveyor General. Walker was posted to the Great Trigonometrical Survey, whilst Robinson was given charge of the survey of the Rāwalpindi and Jhelum districts, his party being designated Topographical Survey, Bengal establishment, No. 1 [208–14].

In 1856 the Orissa party was expanded into two separate units, and on their being formally transferred from the Madras to the Bengal establishment they were designated Topographical Survey of India, Nos. 3 and 4, respectively, Robinson's party being No. 1, and the Hyderābād party No. 2[1]. On Robinson's party being moved to Central India it became No. 1 Topographical Party, Gwalior & Central India[2].

The Hazāra survey had been a civil charge, but on Robinson's transfer to the Surveyor General all his expenses were transferred to the Military Department, so that his "pay abstracts can be regularly settled by the nearest Pay Master".

To defray...expenses connected with the construction of marks and platforms, clearances, and other minor matters of equipment, it will be necessary to furnish him with an advance of Rs. 2,000, to be accounted for in his account current. The bills for such expenses are usually forwarded to me for...countersignature [346], but the Pay Abstracts being regular and systematic are...drawn direct on the responsibility of the executive surveyor.

The establishment sanctioned for the Pindi party was[3]

3	Sub-Assistant Surveyors of the 3rd class	@ Rs. 107 p.m.	Rs.	321
	Hill Allowance for frontier survey	@ Rs. 60		180
1	Tindal	@ Rs. 10		10
6	1st class Flagmen for triangulation	@ Rs. 7		42
6	2nd ,, ,, ,, ...	@ Rs. 6		36
12	,, ,, ,, for detail operations	@ Rs. 6		72
4	Carriers for 12-inch theodolite and planetable ...	@ Rs. 6		24
6	,, small theodolite and planetablers	@ Rs. 6		36
4	,, 3 perambulators	@ Rs. 6		24
5	,, for chronometer, barometer, chains, office tent	@ Rs. 6		30
2	Hurkarars [III, 524]	@ Rs. 6		12
2	Baggage Tents, for public property and Establishment	@ Rs. 22		44
	Total Co.'s Rs.			831

[1] DDn. 643 (259), SG. to Mil. Dept., 11–11–58. [2] DDn. 21 (96, 130), 16–6/12–9–61. [3] DDn. 542 (68), SG. to FD., 4–9–50; sanctioned by FD., 19–9–50; DDn. 541 (246–8).

A native doctor @ Rs. 25 or 30 was added to the establishment later, and the number of surveyors and followers substantially increased.

Depree gives a vivid account of the day-to-day life in a field party [172] ;

We have all our tents pitched in the compound. ... They give the appearance of quite a large encampment. Uncle George [Saxton] and I have 4 dwelling tents, called hill tents, between us, and to each are attached two others for the servants, etc., and in addition to these are three other large ones for...the military guard and lascars.

With 3 elephants (one less than usual), half a dozen horses, a couple of cows, and a flock of sheep and goats, and 150 or more natives dressed in every variety of constume, the scene which our camp presents is somewhat striking. Then, in addition...there are eight sub-assistant surveyors who have each a separate party of 30 or 40 men, ... so you will easily understand that the charge of all these is rather an important responsibility. ...

The soups [183] and tool chest will not arrive in time for us to take them out with us ; we must try and manage to have them sent after, tho' it will be troublesome to do so. We might possibly have got them in time, notwithstanding the delay which occurred in getting them cleared from the ship for they seem to have been put at the bottom of the hold, but on the way up to Calcutta the chuprassi we sent to bring them down was robbed of all his money and clothes and, as he stopped at Midnapore to make his complaint to the Magistrate, much delay has happened. ... We have heard from our agent this morning that the boxes were delivered over to the man only on the 4th inst., so they will therefore just reach Cuttack a week after we leave. ...

We had a fire here the other night ; the sepoys burnt the station billiard room to spite the Magistrate of Cuttack, who has been obliged to punish some of their number, and who was a constant frequenter of the billiard room. The building was next to our house. Rather close quarters you will say when you know that roofs in India are generally made of thatch. ...

You will find Keonjur in the map, that is the country we shall be surveying this year[1].

All parties, trigonometrical and topographical, had to submit periodical returns ;

Monthly :—Progress Report—Report on Government Tents.

Annual :— 1st May ; Return of Instruments.—1st September ; Return of progress and expense—Nominal Roll.

Immediately on return from the field :—Narrative of field operations, in form of a letter.

REVENUE SURVEY : BENGAL PARTIES

There was no recognized limit to the number of revenue survey parties in the Bengal Presidency. The number was constantly increasing after the restart of surveys in the north-west in 1847. In the Lower Provinces the number expanded from four to six. Those in 1844 had been—Purnea Estate under Fitzpatrick—Midnapore under Mathison—district Sāran under Maxwell—Shāhābād, under Walter Sherwill. In 1861 these had become : No. 1, Tipperah District, under Robert Smart —No. 2, Manbhum, under James Sherwill—No. 3, Sylhet, under Nathaniel Davey—No. 4, Bākarganj, under Gastrell—No. 5, Chittagong Hills, under O'Donel—No. 6, Chota Nāgpur, under Hunter Thompson [241–4].

In the North-Western Provinces a new party was raised by Donald Vanrenen in 1847 for survey of Ajmer and Merwāra, and moved in 1848 to Rohilkhand. This was split into two parties in 1852, Vanrenen taking one to Jubbulpore, whilst Burgess took the other to Bundelkhand where it was completely wiped out during the uprising of 1857. A party raised by Dennys in 1854 for the survey of Nimach, moved under Hamilton the following year to Bharatpur, and then under Adrian Vanrenen first to Bundelkhand and then to the neighbourhood of Nāgpur. A further party was raised in 1854 for the survey of Saugor under John Blagrave.

The Punjab surveys were started after the first Sikh war in 1846, parties being raised by Stephen for the cis-Sutlej area and by John Becher for the trans-Sutlej. The first of these was taken over by Shortrede in 1851 and moved to the northern area between the Rāvi and the Indus, and in 1859 transferred to Oudh under Anderson. In 1855 a detachment broke away under Johnstone for survey of Derajāt, beyond the Indus, and expanded into a full party [pl. 16].

[1] Family papers, Depree to his mother, 9–12–55.

From the trans-Sutlej, the second party was split into two, a new party under John Blagrave moving in 1850 into the Bari *doāb*, and in 1859 to Chota Nāgpur under Hunter Thompson. The old party under Thomas Blagrave moved to the west of the Rāvi in 1851 and in 1856 was transferred to Sind under John Macdonald.

Thus by 1861 the Bengal Revenue Survey Department under the Deputy Surveyor General had expanded to 13 parties ; Lower Provinces, 6—Oudh, 2—Central Provinces, 3—Sind, 1—Punjab, 1. The strength of each party varied according as to whether the *khasrah*, or field survey, was carried out by the professional surveyor, as was the rule in the Lower Provinces up to 1851, or under the civil. The *Manual of Surveying* of 1851 laid down two scales of establishment, Double [IV, 216], and Single. That for the double establishment comprised—

1 Revenue Surveyor—1 covenanted assistant—7 sub-assistants—25 to 30 native assistants—170 to 200 *tindals* or *khalāsis*—and *khasrah* establishment "for which a total of about Rs. 37,600 was allowed to cover all charges, including contingencies".

That for the single establishment allowed only 4 sub-assistants and 20 "native assistants", for which a maximum of Rs. 31,500 was allowed. In both cases the Surveyor was allowed to vary his numbers within the allotted funds [IV, 347–8 ; V, 453][1]. Vanrenen's party in Rohilkhand was in 1851 allotted Rs. 3,164 a month ;

European Establishment :—1 Surveyor, Rs. 726—1 Assistant Surveyor (Officer) [396], Rs. 250—1 Assistant Surveyor, uncovenanted, Rs. 300—4 sub-assistant surveyors, Rs. 60.

Native Establishment :—1 Head Writer-Accountant, Rs. 50—1 Head Draftsman, Rs. 50—1 second draughtsman, Rs. 25— 10 native surveyors, Rs. 300—2 office mootsuddies, Rs. 50—1 Persian moonshy, Rs. 30—1 native Doctor, Rs. 25—Classies, Rs. 700—1 Jemadar, Rs. 10—12 burkandazes, Rs. 48[2].

FIELD SEASON

In the early days of the trigonometrical survey in South India it had been Lambton's practice to take his men out to the field during the rains, in order to take advantage of the wonderful visibility of the clear spells. Everest's experience of the devastating effects of "jungle fever" led to the use of luminous night signals which allowed more rapid progress during the healthy months [III, 246–9]. After his return as Surveyor General he announced the principle that there should be no recess season for the Great Trigonometrical Survey ; work should carry on until the fury of the rains compelled a stop [IV, 348, 352]. His experience on the Great Arc, however, and frequent bouts of fever, convinced him later of the need for regular retreat into comfortable quarters for the routine tasks of computation and mapping, and for the recoupment of health.

For the Revenue Surveyors it had been firmly laid down that the working season should extend from 1st October to 30th June, and that whilst salaries for those nine months should be drawn at the full rate of Rs. 618 a month, yet for the other three months a 'recess' salary of only Rs. 250 was allowed. To meet protests from those who were forced to a different programme, it was ruled in 1833 that Revenue Surveyors should draw a flat rate of Rs. 526 a month, taking their three months recess as most suitable for the district under survey [IV, 348 ; V, 398].

As the parties of the trigonometrical survey worked further to the east the greater was the need for flexibility in the period for field operations and, writes Waugh three months after taking charge,

it is...a general rule...to make the most of the favourable season for observation because more detention than desirable is sure to occur at other periods. ... As the favourable season...is the cold weather, it is always prudent to make the most of it. ... By doing so the health of the party is spared, while the quantity of work performed is sure to be satisfactory [457][3].

He advised Garforth to close field work on the Gora Series in good time,

thus enabling you to retire from the exposure of field duty to the comparative comfort and shelter of cantonments. I was not aware that you had intended to continue in the field...

[1] Thuillier & Smyth (307). [2] DDn. 485, 20–3–51. [3] DDn. 491 (20), to Shortrede, 31–3–44.

and, highly as I admire so much zeal and determination, I only hope that you will not...injure your health by keeping...in the field longer than may appear prudent. ... I am perfectly satisfied with your season's work as it stands, and have no wish to take advantage of your zeal to keep you longer in the field than you may think desirable [458][1].

Perhaps the most fearsome climate faced by a surveyor was that of the Gujarāt jungles [55, 460–1, 467] of which Rivers reports that

everyone who has had experience...considers them almost fatal before January. I tried them myself, ... but only thereby crippled most of my best men, not only for the time, but for the whole season. There are positive orders from Government against troops or officers proceeding on duty or on leave through these jungles before the 16th January. For survey operations, however, we have then the benefit of much clearer atmosphere than in the hot months, so if means could be found of keeping the establishment well, I certainly prefer working then[2].

The dry hot months, April to June, were often the most healthy of the year but the heat was exceedingly trying to surveyors in camp. Waugh had designed a "thermantidote" or portable machine worked by hand which delivered a powerful current of cool air. He writes to Logan describing a modification which cut out the objectionable noise caused by the wooden cog-wheels ;

I have made another, ... much smaller, which answers beautifully. It is a light load for two men. If you can sell yours you might make a smaller one. However, do not part with one before the other is ready. ... You will find it a real blessing between March and June[3].

He writes to Du Vernet on the Gurwāni series [12] ;

By the constitution of the Department we are liable to be called into the field at all seasons. I myself have been in the field for the whole or greater part of three rainy seasons, and not one of my assistants ever uttered a murmur or objection. ... But these cases have always been exceptions, founded on urgent circumstances. ... Your [assistants]...are in justice entitled to the usual period of repose and shelter accorded to all successful surveyors to enable them to bring up arrears and equip themselves for the field [409][4].

and to Strange who was in an unhealthy part of Rajputāna ;

It is always a matter of...importance and sometimes of great embarrassment to determine the proper time for taking the field. The old regulations...prescribed the 1st October as the proper date for leaving quarters, a rule from which Col. Everest never departed [IV, 70], but some modification...appears to me...indispensable in peculiar localities. To endanger the health of the party...at the very outset might cause a whole season to be lost. ... The object is to make a judicious choice. ...

The period for returning to quarters...may similarly be regulated. ... When sufficient work has been accomplished to occupy the party fully and completely in quarters in...computation and transcription, it is needless to stay out longer. ... On the other hand, if little work has been executed in the field the party would not have sufficient employment in quarters. ...

No fixed rule can...be laid down, for progress depends on the locality and on the energy and style in which the operations are conducted during the cold season. ... Experience teaches that an immense quantity of work can be executed in 5 or 6 months, or even less[5].

Strange made the most of his difficulties [99, 116–7, 345], but won no sympathy ;

There are many series which are conducted with surprising economy. The Bombay work...only costs Rs. 4–5–3 per square mile. Mr. Logan's operations also are extremely moderate, owing to vigilant control, great management, and the length of his field season.

Mr. Armstrong's work likewise is surprisingly cheap. He takes the field usually in September, and stays out late, generally till June or July, and he is very eager about secondary work which increases his area to an amazing extent, without apparently augementing the expense or giving any trouble. Being a very rapid calculator he is enabled to bring up this vast mass of observations in the field and during a short recess in quarters [415]. ...

I am afraid the cost of your operations will contrast unfavourably with others. ... It is quite out of the question that there can be any real economy when an expensive establishment is maintained during 12 months to perform little more than 4 months work. ... Admitting the necessity of caution, ... it is very unusual for parties that go out so late to return so early as you did last season. The plea made is the impossibility of seeing the signals in the hot weather. This plea is totally inadmissable. ... All the best observations...have been taken in the hot weather, and...every difficult ray on the Great Arc and Ranghir series had to be taken in the hottest weather after 12 o'clock at night. ...

[1] DDn. 495 (44), 18–5–46, but Garforth stayed out till late in August [12]. [2] DDn. 518 (297), 12–6–46. [3] DDn. 499 (47–54), Sept. 1844 ; *v. Curry & Rice* (7), sv. *Our Colonel*. [4] DDn. 524 (96), 8–7–47. [5] DDn. 493 (225), 8–9–49.

The extraordinary early date on which you left the field last season has created very general dissatisfaction among the other parties, who regard it as an instance of undue favour, and a departure from the hardy habits on which this Department has ever prided itself[1].

Strange replied to this emphatic rebuke by 14 paragraphs of argument [345][2].

Waugh protested to Peyton also regarding the early return of the Coast Series year after year, though he had accepted the wisdom of a late start [26]. To keep closer control over all the parties in this matter he ordered that the normal field season should last from 1st October to 30th June ;

When the insalubrious character of the country renders it unsafe to adhere to these dates, a special report...must be submitted annually in due time for the Surveyor General's orders. Any deviation...which may be permitted...is to be...applicable to one season only[3].

He directed the Deputy Surveyor General that "no opportunity should be lost of extending the field season when it can be done safely". On the other hand he allowed both Tennant on the Great Indus Series, and Nasmyth in Gujarāt "to settle the arrangements for your field seasons according to your judgement, in which I have the greatest confidence". To Nasmyth he added "Your health is of great consequence to the Department, and...in arranging for quartering your party you will always take your own health into due consideration"[4].

He was indignant on hearing that Saxton had closed fieldwork on 17th March, leaving triangulation "in the air" and planetablers unchecked, on the grounds that haze prevented further triangulation. He pointed out to Thuillier that haze was of common occurrence and usually dispersed by early monsoon currents, and that officers on trigonometrical survey had frequently to stay out till the end of May or June waiting for a favourable turn in the weather [175].

The same thing has frequently happened to myself, and during 3 seasons I continued in the field throughout the year. In season 1836–7, Mr. Lane remained out observing till 1st August. In the trying climate of Sind this very season Mr. Keelan's party will be out for the whole year, and Captain Walker's levelling operations are being prosecuted under very harassing circumstances [49, 78–9]. ... During Captain Saxton's absence, his successor Mr. John Dyer, though he buried his apothecary, ... continued out till nearly the end of May [173].

You will call upon Captain Saxton to explain more satisfactorily...the causes which have led him to [curtail]...the field season of the large and expensive establishment he controls. ... Captain Saxton is in the habit of quitting his post...without authority. It is the duty of every officer to continue with his party always, and to march with it out of the field, as well as into it. Laxity in this respect has an injurious effect on subordinates. ...

The arrangement of Captain Saxton's remaining at Pooree away from his establishment is also objectionable [386]. ... A great deal will depend on Captain Saxton's personal example in maintaining the field to the latest possible period, and, as Head of the party it is expected of him that he will always be the first to take the field and the last to set the injurious example of a precipitate retreat to quarters[5].

Saxton had a long tale to tell ; even had the weather changed, he could expect no further work from his surveyors. The whole party was saturated with fever ;

The last night but one that I spent in camp, I had no tent to sleep in, and at 11 o'clock I got into a sepoy's tent which did not belong to my own camp, ... there being none but sick men to strike my tent and bring it to the village. ... I had no signallers with me, all not sick being detached. ... My own servants were nearly all sick. ... My cook was very ill—kidmatgar, and dressing servant not...fit for duty. Maitre [sweeper] very ill. The only attendants I had were the cook's mate, who had been ill, and the mussalchee, who was only just convalescent and has since been again laid up. ...

The very few members of the party who were not ill when I retired are all, or nearly all, so now, and I feel thankful...[for] my own escape.

I have hitherto looked upon it as a fixed rule in this survey that field duties were not to be carried on beyond the end of March. ... It is the universal...experience that any attempt to extend operations beyond March would be disastrous. ... Mr. Dyer's remaining out longer was owing in part to the distance he had to return from. His party suffered much, and he buried his apothecary. ... Under me, the party has each time returned thence without suffering much. Captain Depree also remained somewhat later the same season and returned with his whole party laid up, and even after rejoining their regiment several of the guard died. ...

[1] DDn. 616 (106), from SG. 7–10–50. [2] DDn. 517 (354), 23–10–50 (paras 14 to 27). [3] DDn. 648 (239), DO., 29–5–55. [4] DDn. 592 (226), 20–7–55. [5] DDn. 791 (1), SG. to DSG., 12–4–59.

The Khond tract of hills is notoriously the worst of these unhealthy parts. ... I have never ...during the many years I have belonged to the Survey (excepting my first disastrous season) returned from the field in a similar manner.

He pointed out that many seasons ago the Surveyor General had accepted his judgement that it was unwise to take the field before 1st January [463-4]. He had, however, this last season ascended his first hill on 28th December ;

From the 28th December till I reported giving up work on the 17th March...I observed on 51 stations, on some few of which I observed more than once. Of these, 40 stations were on the highest hills in a very hilly country. ... The distances measured on my map...aggregate 343 miles. ... I have nearly 3 quires of horizontal angles, and more than 1 quire of verticals.

The latitudes and longitudes of all the points for current season's detail have been carefully computed in the field, and projected on the planetables by myself. ... The above entailed... exertion on my part which no surveyor has exceeded. This is a strong assertion, but I write anxious to redeem my character. ... I am favoured with a constitution which very few possess and...I never relaxed for a day or for an hour. ...

In computing I worked from daylight and till 10 and even 12 o'clock at night.

He pointed out that the Surveyor General had already agreed to the necessity of restricting the working season to the three months of January to March ;

I am convinced...that any attempt to extend it will fail of success in the end. More work might be done in some years, but nothing to compensate for even an occasional disorganization of the party. ... I consider my past season's work, in practical results, up to the very highest possible quantity. ... I have well supplied the current planetables with triangulated points (1,400 square miles), and have ready for next season sufficient country even better supplied with points for nearly a full season's survey for the whole party.

My junction with the Coast Series, though not on to a base, is effected to one principal station by observation to and from it. I have thus a check for the mass of my triangulation[1].

RECESS QUARTERS

Though as a general rule the revenue and topographical survey parties recessed at the civil headquarters of the area under survey, in order to keep in close contact with the civil authorities, such considerations did not weigh so much with officers of the trigonometrical survey, whose operations might stretch through several districts during the course of a single season and who would be unlikely to deal with officials of any one district for more than two seasons at the most.

For trigonometrical parties, therefore, the main consideration was to secure comfortable weather-proof buildings in a station that was conveniently accessible, with a good climate and, if possible, a government treasury and social amenities. Dehra Dūn was no longer a suitable centre for parties that were working through Oudh, Bihār and Lower Bengal, and the Surveyor General sought to collect the parties either at his own headquarters, Allahābād or Dinapore, or at any rate for two of them to meet somewhere convenient to both. He writes to Logan in 1845 ;

Next season I propose to assemble at headquarters the Karara series, and Du Vernet's and Garforth's parties, which will enable me to overhaul them properly. I have as much reliance in you as in myself, and would be sorry to make you march so far, except for the pleasure of your company. I think, however, that it would be advisable for the Maluncha series to join your headquarters next rains. ... The Calcutta series will be too far off, otherwise I would make it join you also. ... Either Monghyr or Mozafarpur might answer for both yourself and Clarkson. However, all this you can arrange to suit your convenience[2].

Whilst the Surveyor General himself made headquarters at Allahābād from 1844 to '46, he had Shortrede, Garforth, and Walker with him during the rains. Logan and Armstrong recessed together at Digha Castle, near Dinapore[3]. Du Vernet with the Gurwāni Series recessed at Allahābād during 1847 when Waugh was away in Darjeeling, but he had to move to Dehra Dūn himself to prepare for work on the North-West Himālaya series [12, 34, 369]. His sub-assistants were anxious to stay on for the full recess with their families at Allahābād where they had spent

[1] DDn. 668 (75), Saxton to DSG., 6–5–59. [2] DDn. 499 (47–54). [3] Digha Castle taken by SG. from 15–11–46 ; nr. Digha Ghāt on Ganges [13 n.2, 341].

the last two seasons. The Surveyor General agreed that it would be reasonable to meet their request though it meant splitting the party for a few months [366, 409];

As the party have not marched direct on Dehra...new arrangements are required. ... If the sub-Assistants march up in the height of the rains the computations will be thrown into arrears, ... and great risk will be run of the Gurwani Series falling into confusion. ... There will be also some danger of the records being spoilt on the line of march.

The most judicious arrangement...is to leave the Sub-Assistants as a detached party at Allahabad to bring up the arrears of the Gurwani series, for which Mr. Mulheran might be held responsible. ... An urgent necessity exists for your proceeding yourself with your headquarters to Dehra to organise all the public arrangements connected with the mountain series. Establishments have to be enlisted and trained, equipment to be provided, and enquiries to be made. Your relations with the civil and political authorities to be established, and other arrangements, all of which require your immediate presence.

The detached party left at Allahabad will escort the instrument now preparing for you at Dinapore [152–3], ... and also the office tent to enable him [Mulheran] to continue computations on the march. The whole of this party will move on the 16th September...and will be expected to be ready for the field within a week of their arrival[1].

In discussing their joint headquarters, Armstrong writes to Logan in 1849 ;

From what I have seen of Ghazipore I should be sorry to have to canton there. T'is true there are a lot of fine houses available, finely situated on the banks of the river, but their vicinity to the stud lines is a great drawback. The colts...to the number of 3 and 400 are every night let loose in a large enclosure where they kick up a dust as bad as a dust storm which hangs over the whole station about as thick as pea soup, and makes the mornings really quite disagreable. You would be quite disgusted with the place and like most of the residents there you would wish the horses or yourself somewhere else. ...

I think Benares would do very well for us all, and if you were to fix upon the place you would save me a great deal of trouble and expense in moving my family from it. I preferred it to Ghazeepore...and therefore settled my family there. I think Peyton would like it too.

There is no fear of spinsters now there, for Lane and Kirwan [419] took possession of the only available ones and, unless there has been since some fresh arrival on indent, our young hands will have no prospect of any acquisitions worth their while[2].

Waugh criticised Du Vernet's choice of Dacca as recess quarters for the Assam party in 1853, as being too far from field operations near Cooch Behār [29]. He considered that in choosing recess quarters "health, happiness, and comfort" should be the first consideration, and that Darjeeling would have been more suitable and more accessible. Du Vernet justified his own choice ;

I chose Dacca on account of its being a large and populous town, distant only six days journey by water, and seventeen marches of ten miles each by land, at the same distance from the scene of my operations on the Teesta as Bhagulpore, and as healthy as any town in Bengal. ... I might have fixed my headquarters at Darjeeling had I consulted my individual convenience, ... but the native establishment have always had an aversion to hill sanataria. Living at Darjeeling is very expensive for them. ...

There is nothing the native establishment dislike more than residing at Mussoorie, and they always prefer Dehrah[3], ... and I know the feeling...among my party with regard to Darjeeling. They had suffered twice severely from fever during the season, and...many men visiting their homes would not return. ... Men are not to be had at Darjeeling. ...

One house only offered at Gowhatti for...my party. ... The rains in Assam commence as early as March, and I might have found considerable difficulty in reaching Gowhatti in the month of May. ... When returning to the ground...in the ensuing season I could not leave Gowhatti until January, and then marching by Cooch Behar and that unhealthy country on the Barampootra and the Bhotan boundary I could not expect to reach the Teesta with my party otherwise than disabled for field operations. ...

From Dacca...I could march so as to be on the ground...by the end of December, ... through ...provinces...where the rains cease much earlier than in Assam. I think...Dacca was rightly selected as the most eligible place for the headquarters, ... a large and populous town[4].

Later on, from 1855, Nicolson made Darjeeling the party's recess quarters [30].

[1] DDn. 492 (81–5), 8–7–47. [2] DDn. 504 (187), 11–3–49 ; Lane & Kirwan both married in Benares during 1848. [3] DDn. 95 (136–8), SG. discusses, 23–11–69, letter in *Pioneer* of 9–8–69, from "a sub-assistant" complaining of expense of Mussoorie compared with Dehra. [4] DDn. 602 (165), 25–6–53.

The Surveyor General writes to Tennant on the Great Indus series;

Considering the time your party has been absent from my headquarters, and that you yourself have not yet passed any recess in my field office, it would...be a great desideratum if your party...could join me for the next monsoon. ... The isolation of parties is disadvantageous, and the more they can be congregated for the recess...the better. When the field of operations, however, is very distant, the loss of time,...and wear and tear which long extra journeys...occasion, may...counterbalance the advantages of concentration [122, 392]. ...

Your fieldwork will most likely close near Sukkur. From thence my headquarters is about 60 marches. The intermediate country is both salubrious and convenient for marching. ... On the other hand, from the unhealthiness of the country after the monsoon the season for taking the field in Upper Sind is...later than usual, for which reason...the party could very easily return to Sukkur in sufficient time for the next field season. ... Your party could join my headquarters for the recess with every prospect of securing many advantages...with little or no sacrifice. ... The health of your party will be recouped...and satisfactory arrangements made for bringing up computations and for the equipment of the party[1].

In pursuance of these instructions Tennant's party marched up from Sukkur to Dehra Dūn on the close of field work in April 1856, but later in the year took up work on the Jogi-Tila series south of the Rāvi [46, 53].

From about 1852, Robinson and several of the Revenue Survey parties recessed at Murree, and they were later joined by Walker and his officers of the Great Indus Series and the levelling parties. On the other hand Montgomerie took the Kashmir party back to Dehra Dūn every year, and had the invaluable assistance of William Scott and his draughtsmen for fair mapping [225, 238]. In 1861 the Superintendent of Trigonometrical Surveys had five Punjab parties recessing at Dehra.

Waugh always regretted that he could not visit the Coast Series or the Orissa topographical parties, and he welcomed the opportunity of Strange's posting to the Coast Series and recessing at Cuttack in company with Depree [172];

The greatest disadvantage under which the Survey Department...has always laboured is its dispersed state, whereby each party becomes a segregated body with local sympathies and confined ideas. ... To guard against these evils...I have endeavoured...to bring parties as much as possible together, ... the next best thing to a general concentration of the whole[2] [122].

As the Coast Series worked southwards Waugh suggested that it should move recess quarters to Berhampore on the Ganjam coast, but Strange found that it would be impossible to house the party there without...building. The old houses have been suffered to fall to ruin, and there are now only enough barely to accommodate the residents. ... I...propose...that our next recess station should be Vizagapatam, and that we should quarter again at Cuttack next year. ... The benefit derived by associating two parties...is clearly felt...by Lieutenant Depree as it certainly is by myself, and now that an observatory is established here it will...aid considerably in the training...so much desired by you[3] [386, 467].

Cuttack being a military cantonment, Depree was called on to give up his house to a regimental officer, and had to obtain a Government ruling that there was no objection to Survey Officers being allowed to reside within cantonments provided that by their doing so regimental officers are not deprived of suitable accommodation. The latter are in all cases to be served first, but...they are not...to oust Survey Officers from their house when other accommodation as good is available[4].

TRANSPORT

In the days before railways the lengthy journeys involved in moving survey parties and detachments to and from the field or from one distant area to another were a serious consideration. Where the route followed a river, boats were the most reliable form of transport, though exceedingly slow. The Surveyor General's field office took nearly 50 days on the move from Calcutta to Allahābād in 1844 and 109 days between Dinapore and Garhmuckhtesar on the move to Dehra Dūn during 1847–8. Travelling by road, he himself made the journey from Purnea to Dehra in 95 days [337].

[1] DDn. 619 (181), 1–11–55. [2] DDn. 592 (375), 1–12–55. [3] DDn. 697 (66), Strange to SG., 14–8–56; approved by SG., 26–8–56. [4] DDn. 649 (115), Mil. Dept. to SG., 24–9–58.

For journeys in the hills all baggage had to be carried by porters that were expensive and often difficult to procure, but in Assam pack ponies were generally available and cheaper. In flooded and wooded areas elephants were the only practical form of transport. Before 1854 it was possible to borrow elephants from the Commissariat but later they had to be purchased departmentally.

Surveyors and assistants kept riding ponies except in swampy country or the mountains where elephants or *jhampāns* were provided [338, 430]. On the Maluncha series Clarkson sold his mare to the Monghyr opium agent for Rs. 250 but allowed 10 % off for cash payment. "Bill" Rossenrode exchanged his "large mare" for another horse plus Rs. 100, getting "a very good animal likely to answer Bill very well[1]".

Theodolites and other delicate instruments were never entrusted either to carts or pack animals ; professional porters, or *kahār* bearers, had to be engaged either for the full season or stage by stage [II, 334]. In 1854 the base-line apparatus was marched down from Chach to Karāchi by bullock cart. The ten carts cost Rs. 1-4 each per diem and the journey took from the first week of March to 30th May [43, 158]. The carts had to be maintained six months at Karāchi for the return journey to Dehra Dūn. Keelan who was in charge of the move reported that he

experienced great difficulty in accomplishing the march from Roree to Hyderabad. The road throughout is intersected by numerous canals ; sometimes as many as 15 or 20 were crossed in one march. The banks of several of the large ones required to be cut and reduced...to admit the carts through them. ... I deemed it necessary subsequently to employ a pioneering party with one of the dafadars...to prepare the road in advance. ... The cattle have suffered considerably from this portion of the march, and several of them are quite exhausted, ... so that it was found necessary as occasion required to supply the carters with fresh cattle. ... One of the four Government bullocks engaged at Mooltan died on the 11th inst[2].

On his posting to charge of the Coast series Strange's journey from Dehra Dūn to Cuttack occupied him from 17th October to 26th December. Rossenrode was transferred from Karāchi at his own expense. Whilst he himself sailed by sea from Bombay to Calcutta, he had to send his servant and baggage by land. He petitioned for refund of his expenses ;

My transfer...to Cuttack...has...subjected me to very heavy expense, not only in transporting myself...by sea (paying a high rate for my passage), but...I had to dispose of my property at a great sacrifice, and I am now being put to much expense to refit myself. ...

When the...order...came to hand, I was at Bombay, whither I had proceeded...in anticipation of 6 months leave, ... leaving all my baggage at Kurrachee. ... I availed myself of...opportunity to send a servant thither with directions to sell off the bulk of my property including tents, horses, etc., at any price they may fetch, and taking charge of the remaining valuable books, ...and other articles which could not be easily replaced, to proceed...overland to Cuttack by the safest route. ... The sale of property was effected at a great pecuniary loss. ...

From Kurrachee to Hyderabad, Aumercote...Balmeir...Jodhpur...Nusseerabad...Agra... Mainpoorie...Futtygurh...Cawnpore...Allahabad...Benares...Cuttack. The servant...left Kurrachee on the 4th August and arrived at Nusseerabad on the 10th October last, his progress being greatly impeded by the heavy rains which fell this season. ... My men, camels, and baggage will not reach me by even the end of December next. ... Had I proceeded by land I should have been unable to join the Coast Series till the working season was far advanced[3].

The sea passage from Calcutta to the west coast was cheaper and quicker than the land journey, but had its hazards. Two cases of stationery sent from Calcutta for the Hyderābād party working in Berār were lost by wreck of the steamship *Ava* near Trincomalee[4].

Journey between important centres could be made along main roads by *dāk*, carriage, or palanquin—with horses or bearers changed at regular stages. Special sanction had to be obtained from Government for charging the cost of a *dāk* journey carried out on duty [IV, 124]. The double journey between Dhārwār and Poona by ordinary stages took 40 days ; by *dāk* it took only 8[5]. On Beverley's move from

[1] DDn. 504 (500), Clarkson to Logan 8-10-44.
[2] DDn. 612 (56), Keelan to SG., Kotri, 21-5-54.
[3] DDn. 589 (247), Rossenrode to DSG., 3-11-54.
[4] DDn. 691, from Mulheran, Ellichpur, 29-3-58.
[5] BO RC. 164 (111-2) ; Goldsmid to Bo. Govt. (1847).

Calcutta to Meerut in 1854 he had to pay Rs. 245 for seats for himself and his servant, in one of the "Inland Transit Carriages". Neuville and Ryall made the same journey "by horse dak" two years later, "a seat each inside and an outside seat for one servant[1]" [IV, 170–3].

BOATS

Arrangements for the hire of boats for journeys on the Ganges and other main waterways were made by indent on the Commissariat Department [IV, 170]. A fleet of 22 boats of various sizes was required for the move of the Surveyor General's field office from Dinajpore to Garhmukhtesar, a three-months journey, under Webb the Registrar [341]. Except for the sinking and retrieving of one boat without serious loss he had less incident to report than had Morrison in 1833 [IV, 170–2].

Radhanath Sickdhar made the down-stream journey with two of his computers and his records between February and May 1849 [341, 355]. The journey was

protracted to two months and 19 days...from Ghermuktesar Ghat...[by] 1st.—Easterly winds—2nd. the shallowness of the Bhagirathi and southerly and south-easterly winds[2].

With regard to the easterly winds...the daily progress was always very small. On many occasions...the boats, even with the aid of the goons[3], could not make head against them. ... When this occurred we were necessitated to halt and wait for more moderate weather. We left the channel of the Ganges and entered that of the Bhagirathi on the 13th ultimo. ... As the whole voyage down the Bhagirathi was performed with the aid of the goons it occupied a period of 20 days, the date of our arrival at the Presidency being the 2nd instant[4].

On his journey from Dehra to Karāchi in 1854 [44], Waugh took boat down the Sutlej from Ferozepore, and then marched from Tatta to Karāchi with camels. The Commissary at Ferozepore wrote that

in all October a voyage down the river can be performed with safety and expedition. In September you could travel quicker, but it is generally very unhealthy, and near Sukkur somewhat dangerous. The boats on this river are of all sizes from 300 to 1,200 maunds, and are fitted up with grass mats and in the form of native huts. ... They are, however, very comfortable, much more so than native boats...upon the Ganges. ... From this ghat to Sukkur, Hydrabad, and Tatta there is a regular nerrick [scale of rates][5].

For the return journey Waugh sent his office up to Multān "by one of the steamers of the Indus Flotilla [IV, 244, 476], whilst he himself went by sea to Calcutta".

Revenue Surveyors were strictly warned against

trusting Government property on the great rivers in boats, as Mr. Pemberton has recently reported...the loss of all his Government property by the sinking of his boat in progress from his camp to Berhampoor. Government instruments should never be trusted off dry land except where absolutely necessary to cross rivers[6].

ELEPHANTS

Each of the revenue survey parties working in Lower Bengal and Assam was provided with five or six elephants from the Commissariat Department, but in 1851, "as there was not a sufficiency of elephants with the Commissariat Department", replacements were supplied from the Dacca depot. In 1855 the elephants of Gastrell's party were lent "to the Military Department for the use of the troops against the Sonthals [499]. The elephant reported to be with young has been returned...as not fit for work until after giving young". Thuillier ordered that "every care should be taken of the animal with young, and she should be worked very quietly after giving birth to it"[7].

As a general rule the surveyors knew very little about the management of elephants, and there was a sad number of casualties. From 1854, Surveyors had

[1] DDn. 662 (81), 8–3–50 ; v. account of this "box on wheels" in *The Timely Retreat*, I (85–128). [2] The old Cossimbāzār R., through Murshidābād to the Hooghly [I: pls. 13, 24]. [3] tracking ropes [IV, 475]. [4] DDn. 567 (3), Radhanath to DSG., 12–5–49. [5] DDn. 644 (37), DACG. to SG., 20–3–54. [6] DLR. 36/29 (101) ; DSG. to Wyatt, 29–5–55. [7] DLR. 36/25 (12), Bradley to DSG., 20–10–55.

to make their own purchases; "good animals may be had in Mymensingh and Sylhet". Prices ran to about Rs. 600 each.

Elephants were imperative for the Assam party [338], and Du Vernet reports that on assuming charge in December 1852 he found

the party suffering from fever, and...my sub-assistants having great difficulty in procuring carriage for their baggage. Bullocks and tattoos [ponies] are not suitable...for the country, neither are carts or camels, there being no roads for the former. ... Camels die in such moist lands, and...the country being flooded and intersected by numerous small rivers containing much water, and there being many swamps and morasses the only appropriate carriage are elephants.

These animals cost about 250 or 300 rupees when first caught, but until they have been several years in bondage they are useless, and a trained elephant costs 500 to 600, a sum far beyond what any young assistants on their pay of Rs. 107 can afford, or even my senior on his allowance of Rs. 259, and elephants cannot be hired on any terms.

He asked for each sub-assistant to be allowed the use of a government elephant, and for "two additional elephants...for...tracing rays, horses...being unsuitable, if not altogether useless, the country abounding with wild beasts"[1].

In Orissa Saxton asked that he might be allowed elephants from the Bengal Commissariat Department, instead of from Madras [172];

I am now saddled with the preparation of a number of monthly documents, ... especially inconvenient in the field. I applied to the Madras Government to be relieved from this, but... my request was not granted. The feeding bill is for rice, oil, and salt, the daily accounts in Madras seers, the purchase effected in Cuttack seers. ... The most unsatisfactory kind of document to prepare, which I am obliged to do myself. ...

I have hitherto had 4, which have been sufficient. Two...as my private carriage, for which I pay...according to the regulated number of bullock loads they are fixed to carry. ... One Elephant...as my reconnoitring animal. The fourth carries the observatory tent and a lot of undefined property in the way of supplies belonging to the native establishment. The two latter...are...often used as conveyance for sick men. ...

The cost to Government for the 4 elephants...for the 12 months just past, including the annual supply of new furniture, is Rs. 1,187-8-2, or nearly 100 rupees per month. In addition to this I have 20 bullocks, each at Rs. 3 per month, which are distributed amongst the different parties and military guard, for carriage of supplies[2].

Nicolson had learned something about elephants on the Parasnāth series [15-6]. In 1855 he recommended their purchase in Assam;

The prices of elephants have risen considerably within the last two or three years owing to the great demand...for them in the Upper Provinces and the railway works, but...I...will be able to procure good working animals for about 6 to 7 hundred rupees apiece.

There are at present three Government elephants of Dacca depot...with this party, but I would not recommend their being retained for good...as they are not strong and healthy animals; besides, two of them are undersized, ... the keep and feed of which cost nearly as much as of large ones, and yet they carry only half the weight. ...

Elephants are indispensably necessary for the...Assam Longitudinal series—Office Tent, with small tent, blacksmith's shop and store box, weighing 30 maunds, 2 elephants—Four office, and two medicine boxes, and also a trunk containing cash, native records, etc., 1 Elephant—Observatory Tent, with a box containing candle-wicks, chimney glasses, blue lights, etc., weighing 12 maunds, 1 Elephant.

On a good road a large-sized elephant will carry about 16 maunds with ease, in addition to the gear and mahout's property which alone weighs 4 maunds, but going across paddy fields during wet weather it will be necessary to reduce the baggage[3].

On this report the Surveyor General obtained authority for a total of 15 elephants—Assam and Orissa parties, 4 each—Coast Series, 3—Hyderābād Survey, 2—Surveyor General's field headquarters, 2[4]. He was authorized to make the purchases departmentally. Two, "well known to be of a superior order", were purchased for the Coast Series from John Peyton on his retirement, the Surveyor General writing;

As elephants are a great charge against the Series, they must be carefully used—not overloaded—and fed and kept with the utmost economy. ... In an unfavourable climate the use of elephants will tend greatly to preserve the health and maintain the efficiency of the party. In a hot climate and jungly country a tedious march on horseback at a slow pace is very

[1] DDn. 602 (125), to SG., 1-1-53. [2] DDn. 429 (3), 14-1-55. [3] DDn. 703 (67), to SG., Jan. 1855. [4] DDn. 549 (148), from SG., 11-7-55; 577 (19), from Mil. Dept. to Cómmy. Gen., 17-8-55.

exhausting, and it is precisely when the vital energies are thus weakened that any malarious influence...is most likely to take effect. Malaria...is always in a more concentrated form near the surface of the ground. ...

A march through jungles, marshes, and wet lands can be very rapidly performed on an elephant without fatigue or exposure to the sun, the rider being well elevated above the ground, and exposed to the genial influence of fresh air. ... Thirty rupees per mensem, with the saving of the horse allowance should amply provide for 2 elephants in Orissa[1].

Robert Scott was deputed to purchase elephants at the Hardwār fair and, with the help of a committee convened by the military officer in command, two were purchased for Rs. 1,336 the pair, and sent off on 5th of May 1857 from Dehra Dūn, destined for Depree's party at Cuttack. They left, writes Waugh, under charge of Ramlagan Singh [of district Ghazipur] and Fakiruddin [of Tirhut], chuprasis of my public establishment, and attended by two mahouts and two charcuttas [grass-cutters]. The chuprasis were directed to proceed...by the usual route via Meerut, Allygurh, Allahabad, etc., and Ramlagan Singh was further ordered to transmit progress reports [and]...furnished with paper and with envelopes franked [452]. ... The party arrived safely at Meerut on the 10th May[2]...but since that date no definite intelligence whatever has reached me. ... Ramlagan Singh was entrusted with...cash and drafts...for...other road expenses[3].

After extensive enquiries news came from the Commissary at Allahābād that Chuprassy Ramlagan Singh brought the elephants to me on the 25th of June 1857, and as cattle of all kinds (especially elephants) were most urgently required for the equipment of the troops, ... they were retained by me, and were disposed of as follows, vizt.,

Elephant Soondur—mahout Gulab Khan—transferred to Cawnpore with Genl. Havelock's force, on 8th July 1857. Elephant Motee—mahout Munnoo Khan—transferred to Cawnpore with Genl. Outram's force on 5th September 1857. The latter elephant...was not transferred with the other being at that time in low condition.

As these elephants cannot now be recovered and returned to you, they being employed with troops on service, I would suggest your debiting their value to the Commissariat Department[4].

The Magistrate at Benares reported that the elephants had been plundered in June last by rebels on the Grand Trunk Road, and presented...to the Raja of Manda in pergunnah Khyragurh[5], who sent them to the Magistrate of Mirzapore. The latter officer sent them to Allahabad, where they were made over to the Commissariat, and receipts for them given to Ramlagan chuprasee[6].

Ramlagan Singh had been robbed of all the money and drafts at the time the elephants had been first siezed, but he stuck to his charges and worthily fulfilled his trust [483]. In due course the Orissa parties completed their establishment of elephants by local purchase, and by the arrival of three that were purchased for them by Lane in Assam[7].

RAILWAYS

Railways were introduced into India on the authority of a letter from the Directors dated 7th May 1845, and on the arrival of their engineer, Frederick Walter Simms brother to the famous instrument-maker, a Railway Committee was formed in Calcutta comprising Simms and two engineer officers, Alexander Boileau and James Western [IV, 421–2, 474]. This committee made full use of the maps in the Surveyor General's office for their preliminary plans[8].

Besides calling on the Survey for maps, the Railway Engineers asked that frequent spot heights at "obligatory points" should be shewn on all maps. They were a constant source of anxiety to the Surveyor General by tempting away many promising young surveyors by the lure of more generous salaries.

The earliest sections of railway to be opened were[9] [pl. I]—

Howrah to Raniganj, 1854–5—Khana (nr. Burdwan), to Kiul, via Bhagalpur, 1858–62—Allahabad to Ghaziabad, 1859–64.

[1] DDn. 600 (154), SG. to Strange, 1–12–55. [2] the very date of first outbreak of mutiny at Meerut [482]. [3] DDn. 645 (337), SG. to Comnr. Meerut, 27–0–57. [4] DDn. 664 (11), DACG., Allahābād to Depree, 23–12–57. [5] Khairagarh, southern *pargana* of Allahābād Dist., Manda subdn., being 20 m. W. of Mirzāpur. [6] DDn. 646 (362), to Cmnr. 4th Div., 6–4–58. [7] DDn. 657 (227), Lane to Saxton, 16–12–57. [8] Sandes, II (104–5). [9] *Ind. Rlwys.*, 1942 (83–5, 112, 165).

Karachi to Khotri, nr. Hyderabad, 1861 ; Amristsar to Lahore, 1862.
Bombay to Thana and Kalyan, 1853-4—to Nasik and Chalisgaon, 1861, to Bhsawal, 1863—Broach to Baroda, 1861.
Madras to Jalarpet, 1860.

ALLOWANCES

When Du Vernet's party took up work in the Punjab hills they drew hill marching allowance @ Rs. 100 for the officer in charge and Rs. 60 for each assistant [35], compared with the allowance of Rs. 200 p.m., allowed to Hodgson and Herbert in 1818 [III, 348], and this was extended to Robinson's party, which would, writes the Surveyor General, "be employed in a rough hilly country, and in distant localities not entirely free from danger, where they will be exposed to enhanced expenses[1] ".

In recommending your party for this indulgence, I had particularly in view the nature of the work across the Indus, and it was my intention that this allowance should not commence till your party moved across that river [209-10]. As your operations, however, along the Jamu boundary will lead you into connection with Mr. Logan's mountain series, I conceive your party will be entitled to the allowance so long as you are engaged on that line.

When you commence the series along the Salt Range, this extra allowance must cease as it will create an inconvenient precedent in the case of other survey parties. ... You will... cease drawing this allowance at the Jhelum[2].

This "hill marching allowance" was continued throughout the Pindi survey, and was extended in 1860 on the move to Central India[3]. In 1860, his last year in office, Waugh made an unsuccessful plea for its extension to the two Orissa parties ;

The unhealthy character of the climate is...notorious. ... Difficulties are further aggravated by the barren and unpopulated character of the country, deficient in wholesome supplies and every requisite for civilised existence, of which all...articles have to be brought from a great distance. ... Camp followers, decimated by sickness, require high wages. ... The salaries of the surveyors are totally inadequate to meet the heavy charges devolving on them, and they are thus exposed to additional risk from want of ordinary comforts. ...

The regulations regarding sick leave are, moreover, so stringent as to be altogether a bar to new hands, to whom frequent attacks of sickness is a matter of certainty...so long as these tracts remain in their present wild state. ... It is no wonder that the service is unpopular, that it is difficult to obtain recruits, and that the old hands are dissatisfied. ...

To me it is a painful duty to urge forward the work under such circumstances. ... I have lately recommended that the allowance of 60 rupees a month throughout te year...should be extended to these two establishments. No orders...have yet been received. ... What I have recommended partakes of the character of a temporary alleviation suited to the immediate emergency. ... Further improvement in their prospects, and a greater assimilation to the advantages enjoyed by other Government servants will be needed[4].

At the same time he made an equally unsuccessful plea for the introduction of regular travelling allowances for all ranks right through the Department ;

The allowance of Rs. 60 in itself is insufficient to meet the heavy expenses incidental to constant travelling over every variety of country, hilly and plain, including desert. ... If it were allowed only during the field season [it] would entail a serious loss, ... but by being treated in the nature of a contract and drawn throughout the year, it tends to cover all expenses and works efficiently and economically [361]. ...

This arrangement...has been extended to several parties of the G.T. Survey and topographical survey and...I recommend that it may now be extended generally throughout the Department. ... Rs. 100 per mensem...on the same conditions...was also granted to Executive Officers, ... which might also be made general. ... Considering that the field season...extends over 8 months, except in particularly unhealthy localities, and that a surveyor must keep up his travelling equipment all that time, and also pay return hire sometimes for very long distances for his carriage, ... the scale...prescribed for the Department Public Works...would be a more expensive arrangement[5].

[1] DDn. 542 (468), SG. to FD., 4-9-50. [2] DDn. 588 (37), to DGR. 28-9-50. [3] DDn. 642 (535), FD., 5-10-& Mil. Dept. 10-10-60, to SG. [4] DDn. 594 (361), SG. to Mil. Dept., 6-10-60. [5] PWD. scale, Rs. 5 daily for Ex. Engrs. and Rs. 4 for assts. for actual journeys ; DDn. 2 (30), SG. to Mil. Dept. May, 1860.

The Surveyor General included these monthly rates for the full year in his first budget estimate, but on the Auditor General pointing out that provision for travelling expenses had been made when fixing the original rates of salary, Government declined to accept the proposal [I : 277 ; V, 407–8]. The matter was taken up again by Colonel Thuillier in reviewing the full subject of salaries and allowances. The whole organization of the Department was then subjected to a minute scrutiny by a special officer, Colonel Dickens, and establishments and salaries worked out on entirely new principles, came into force in 1865 [399, 408 n.2].

Salary bills were drawn on monthly abstracts endorsed by military paymasters and cashed at the nearest treasury. During the troubles of 1857 it was impossible to ensure the regular issue of salaries ; treasuries were being sacked, and the movement of treasure along public highways became impossible for several months. The Chief Commissioner of the Punjab issued instructions to the Paymasters :

Money is already scarce and the want of it at this crisis will shortly prove our greatest difficulty. ... The pay of all servants of the Government, whether civil or military, with the exceptions hereafter mentioned[1], shall gradually be kept 3 months in arrears. Pay for June to be issued in August—for July in October—for August in December—for September in January, and so on regularly. ... No deviation whatever from the above rules can be allowed [483][2].

GUARDS & ESCORTS

In the days of Lambton and Everest the Great Trigonometrical Survey had maintained its own private escort, and when the Surveyor General toured the country he was accompanied by a military escort befitting his rank [II, 358–9 ; III, 406–7 ; IV, 410–2]. It was not until 1842 that the G.T.S. escort was finally broken up and it was ruled that a personal escort would no longer be allowed to the Surveyor General [IV, 412]. He was to be allowed an escort on special occasions only for the protection of valuable instruments or records.

Military guards were now only allowed to surveyors working in dangerous areas, and then only after obtaining the authority of the Surveyor General to apply to the local military commander. Protection for survey camps was normally to be furnished by armed civil *barkandaz*. Local escorts were provided for surveyors conducting principal triangles across the kingdom of Oudh, and Du Vernet wrote to the Resident at Lucknow asking for an escort of "shooter sowars" [473].

Renny had an escort when starting the Great Longitudinal series from Sironj in the Central India States, and he writes to the local military commander[3] ;

I have on duty with me an escort...—Cavalry, 1 daffadar and 4 sowars—Infantry, 1 havildar, 2 naicks, and 20 sepoys—of the Bhopal Contingent, which I will be obliged by your relieving, as I will shortly be nearer Aumjur than Sehore, the headquarters of my present escort. I received the guard of Infantry originally from the Meerut Division, and it has been regularly relieved at every military station I have passed through, the brigadier at Gwalior giving me a relief from Scindiah's Contingent on my arrival at Gwalior, which was...relieved at Sippree[4].

The detachment of cavalry I received on coming within the Bhopal Political Agency, and I have found them of great use in facilitating...my operations amongst the many small States, ... the presence of a sowar with my detached parties ensuring them a civil reception. I will be obliged by your increasing the number of sowars to six[5].

For his triangulation through Kumaun and Rohilkhand on the North-East Longitudinal series two years later Renny asked for a guard of 1 havildar, 2 naiks, and 14 sepoys, from the Goorkha battalion at Dehra,

with reference to the mountainous country I shall be engaged in. ... In addition to a guard for myself, and protection for the very valuable instruments under my personal charge, I have generally 2 guards detached for the protection of instruments sent with my assistants, or for the escort of our pay from the nearest treasury[6].

[1] pay of troops and armed police. [2] DDn. 646 (92), to Dep. Pymr. 21–7–57. [3] at Agar, 40 m. N. of Ujjain. [4] [IV, pl. 4], now Shivpuri, 60 m. S. of Gwalior. [5] DDn. 516 (116), 1–1–49. [6] DDn. 569 (120), to AAG. Meerut, 4–9–50.

Du Vernet warns one of his sub-assistants as to the employment of the military guard attached to his camp in an unsettled Punjab district ;

Your guard is supplied, not for show or...from your rank. You have not any right to it but for the protection of public property. If you were to use it for the purpose of intimidation or, by putting natives in [custody under] your guard, bring upon you the civil power, the consequences might be most serious to you. ...

Consider your guard entirely under the command of the naique, and hold him responsible for their good conduct. Order no punishment—you have no military authority—and never interfere with the naique when he orders his men extra duty. ... Warn the naique to keep his men clean, and look to their arms and accoutrements once a week, as well as insist on the regular relief of sentries at night, and to their being alert on their posts.

Desire that he will not...employ begaries without paying them[1]. Be kind and considerate to the sepoys. ... Never detach sepoys or allow them to be absent from under the orders of the naique. If you require cash from a treasury make up a party...of barkandazes and trustworthy lascars, but send no sepoy unless you send the naique with the whole guard.

Never employ sepoys to obtain supplies or coolies. The district chuprassies are allowed you for this duty, and if you have no district chuprasies, send a barkandaz to procure what you require through the headman of the village. ... If the head man...refuses you assistance, or says that he has not the means, request him to give you a writing to that effect. The tehsildar is the person to whom you should refer.

If...your people should be so unfortunate as to get into a quarrel with the villagers, call them away, and on no account allow others of your party or your guard to go to their rescue[2].

The Surveyor General insisted on a sufficient guard to allow a double night sentry over the field office at Dehra Dūn ;

In the time of my predecessor a larger escort was employed, and he had always a personal guard as a field officer at the head of a department. I have dispensed with this honorary distinction, and with the view of reducing the requisition to the smallest limits compatible with the safety of my depot of instruments and records have applied for only a single sentry at my office in the hills, and a single day, and double night, sentry on my depot at Dehra. ... On one occasion part of the pendulum apparatus was stolen, since which time it has been usual to post a double sentry over that property and over the treasure[3].

Military guards were necessary with the trigonometrical parties working along the north-west frontier, and also with Robinson's party in Rāwalpindi District which, writes the Surveyor General,

though materially pacified under its present rigorous government, still continues unsettled and liable to petty outrages, ... and along the Indus is subject to invasion by marauders from the Khuttuck tribes. ... In the early part of the present year a party of signal men detached with valuable instruments a few miles from my camp, whilst I was employed on the measurement of the Chuch base, was set upon by robbers, and three of the men stabbed. The necessity, therefore, of protecting Lieut. Robinson's several detachments appears to me very urgent[4].

During 1858, when the wide extension of military operations made it impossible to spare troops for escort duties, Robinson was allowed to maintain an armed civil guard of 1 jemadar, 1 naib, and 28 *barkandazes*[5], and a special police company was stationed at Dehra Dūn for the sole purpose of supplying guards to survey parties[6].

The topographical parties working in Orissa were also provided with local civil guards, as their camps were scattered through wild country and, writes Saxton,

I fully expect that a guard of regular sepoys will be placed at my disposal by the Madras authorities...in case of a sebundy guard not being available[7]. In the event of all aid being refused beyond our local means, ... we shall not be deterred from taking the field. No. 2 Party is provided for by the promise of a naib guard of 15 men, and Lieutenant Depree is organising a party of barkandazes armed with muskets, and now being drilled.

For No. 1 Party the Commissioner of Cuttack has promised that the tehsildar in the Boad Hills who has a tolerably strong party of naibs, and is an energetic man, shall render me all the assistance in his power. ... I am not anticipating any more than usual hostility...but when it has been thought necessary to locate so strong a force as is now at Sambulpore, ... a survey party working in the neighbourhood should be amply protected[8].

[1] forced labour [III, 399, 523]. [2] DDn. 536 (213), Du Vernet, from Samna Banj HS., NE. from Gurhagarh, to John Dyer, 14–4–50. [3] DDn. 543 (74), SG. to Kumaun Batt., 20–4–53. [4] DDn. 547 (292), SG. to AG., 15–12–54. [5] DDn. 687 (5), SG. to Robinson, 3–6–58. [6] DDn. 152 (22), SG. to Keelan, 13–9–58. [7] cf. *najib* [IV, 413] [8] DDn. 728 (5), Saxton to DSG., 28–11–58.

Two years later Depree reported that the 9th Bengal Police Corps

stationed at Cuttack has received orders to furnish no escorts in future to the survey parties, ... consequently the Madras regular army will be called upon. ... The sepoys of the Madras army being natives of lower India are unused to the unsalubrious climate, ... and...suffer in a grievous manner from its influence. ... Regular troops in tight red coats are not so well adapted to the rough work of a surveyor's camp in a hilly jungly country. ... On the other hand the Police battalion is formed entirely of men of their district and of the hilly country of Goomsoor. ... They are therefore not affected by the climate, as proved by the experience of each year since 1856–57. I have since my return kept up a guard of chuprassies and kalassies, but as the field season approaches, their services will be otherwise required[1].

The matter was referred to the Military Finance Commission, which ruled that the provision of military or police guards to protect instruments and records of survey parties, either in cantonments or in the field, was a great waste of public funds, and orders were issued that survey units should provide their own guards ;

As to instruments and plans, etc., ... they offer few temptations to ordinary thieves and robbers. Hence they need no military guards to protect them against violence or forcible abstraction by organized bands. All they require is of that kind which can best be rendered by the trained servants of the Department. ...

As to protection against private theft, it is abuse of the...military system to permit such duties to be imposed on soldiers. For the keeping of funds the banking system is far the best. ... All pay and other large sums should be disbursed immediately on being obtained from the treasury but, if any guarding is needed for temporary occasions, ... that duty ought to be arranged for by the Department itself. ... We consider that to take a soldier, who is trained and maintained at a great expense for...special military duties, and employ him upon work that any peon is able to discharge, is as wasteful as if the Surveyor General were to employ his best calculators on copying work[2].

It was thereupon ruled that all survey parties should maintain a sufficient establishment of *barkandaz* guards to provide protection both in field and recess[3].

[1] DDn. 679 (91), to DSG., 16–7–60. [2] DDn. 594 (410), Mil. Fin. Comm. to Mil. Dept., 22–12–60.
[3] DDn. 701 (118), DO., 18–12–60.

CHAPTER XXIV

MILITARY SURVEYORS

GREAT TRIGONOMETRICAL SURVEY : *Appointments — Promotion — Training* — TOPOGRAPHICAL SURVEYS : *Madras & Burma — Hyderābād — Ganjam & Orissa — Punjab — Kashmir* — DISPUTES & CENSURE :— *Shortrede — Rivers — Du Vernet — Saxton* — REVENUE SURVEYS : *Bengal — Bombay* — SURVEY ALLOWANCES — NOMINAL ROLLS : *G.T.S. — Topo. Surveys — Revenue Surveys : Bengal — Bombay & Berār — Madras.*

WHEN he took over duty in December 1843, Waugh had only four military officers under him in the Great Trigonometrical Survey : two from engineers, Renny and Rivers, and two from infantry, Du Vernet and Shortrede. Garforth of Engineers joined in March 1844 but Renny took furlough in July, and Shortrede reverted to regimental duty eight months later [391]. Their places were taken by Reginald Walker, a young engineer officer, and Thorold Hill, Madras infantry, with several years experience on topographical surveys [IV, 361, 447].

Garforth resigned after two seasons in charge of the Gora series ; he "had not exhibited a turn for the duties [12]". Walker was an outstanding success in charge of the Maluncha series, but died at the end of a particularly exhausting season in April 1847 [14, 19]. Hill had worked many years in the wild hills of Goomsur, and the Directors thought that his experience would be useful in conducting the Coast series through the formidable obstacles of Orissa. He had continual fever, and after several spells of leave was forced to resign [22–5].

Renny returned from furlough in 1847 in time for the measurement of the Sonakhoda base-line. He then took over the Maluncha party and started it on the Great Longitudinal series running west from the Great Arc, but handed over to Strange in 1849 in order to assist at Dehra Dūn in the capacity of Astronomical Assistant [20–1, 37–8]. After the death of his father in 1849 he assumed the name Renny-Tailyour, and resigned for family reasons in January 1854. His retirement was a serious loss to the Survey ; he had joined but one month after Waugh, and like him had won Everest's complete confidence [IV, 357].

Strange was appointed from Madras cavalry at the end of 1847, having attracted attention by his uncommon skill in repairing and adjusting scientific instruments. After taking over from Renny he carried the Great Longitudinal series across the deserts of Rājputāna and Sind. He took over as Astronomical Assistant in place of Renny, and was then transferred to the East Coast where he fell seriously ill. Taking two years sick leave to the Nīlgiri Hills he was entrusted by Waugh with the design of a new 3-ft. theodolite, which eventually proved too heavy for field work [151–2]. After promotion to regimental major he retired in 1860 and became Inspector of Scientific Instruments at the India Office in London.

Like Shortrede [IV, 466], Du Vernet was never a great success on the trigonometrical survey. He had served on topographical surveys in Madras, and was brought in to the G.T.S. during the Afghān troubles when young officers were not to be obtained. After several years on subordinate series in Bengal, he started the North-Western longitudinal till Logan became available, and then held charge of the topographical survey of the Punjab Himālaya [200–4]. At the end of 1852 he was, to his deep disgust, transferred to the Assam longitudinal series. His work did not meet Waugh's approval, and he was allowed to resign to join the telegraph department in Burma [141, 393–5].

In 1850 Waugh pressed for the appointment of two young military officers to be put under training till fit for independent charge when required [382], and during 1851 and 1852 two engineer officers, Tennant and Montgomerie, were posted as assistants to Strange and Logan respectively. Both succeeded to charge of field parties within three years and proved themselves practical geodesists of the highest order. Tennant left in 1859 to act as Astronomer at Madras, and later became Mint Master at Calcutta. He is best known for his astronomical observations of solar eclipses and the transit of Venus. Montgomerie distinguished himself by ten years charge of the Kashmir survey, and later by organizing and controlling the work of the trans-Himālayan explorers [448–9].

Two valuable engineer officers were found in Robinson and James Walker who after the occupation of the Punjab were employed on military surveys on the north-west frontier, before being transferred to the orders of the Surveyor General [208–17]. Robinson proved an exceptionally fine topographical surveyor whilst Walker was an outstanding geodesist who succeeded as Superintendent of Trigonometrical Surveys in 1861, and became Surveyor General in 1878 [340–1].

On the Bombay side Rivers dropped out in 1853 and was succeeded in turn by two very capable engineer officers, Nasmyth and Haig.

James Basevi, appointed in 1856, was after Walker the greatest geodesist of all Waugh's recruits. He made a success of everything he touched, and closed a devoted life beyond the Himālaya making pendulum observations under the severest conditions. A promising career was cut short when Elliott Brownlow lost his life at the capture of Lucknow in March 1858; he had the distinction of making the observations in 1857 to K2 and other giants of the Karakoram that intersected with those of Montgomerie the year before [88, 229, 483].

The last appointments made in Waugh's time were Branfill of the cavalry—John Herschel, able descendant of his more famous father and grandfather—and Harry Thuillier, son of the Deputy Surveyor General, who was Surveyor General in his turn between 1887 and 1895. The appointments made to the Great Trigonometrical Survey under Waugh comprised 13 Engineers, 2 Cavalry, and 1 Infantry officer [399]. In recommending Strange's appointment he commented that "The practice hitherto followed since the time of Colonel Lambton...has been to select the best qualified officer without reference to the branch of service he belongs to, and this system works well" [IV, 357; V, 390].

The office of Astronomical Assistant was initiated in 1832 to enable an officer with outstanding qualifications to be employed in executive charge of a field party or on special duty as occasion arose. The post caused no increase to the existing establishment; it carried the same pay as that of 1st Class Assistant, but not, as first suggested by Everest, additional to that allowance. The office was, in effect an honorary one, but greatly appreciated [IV, 353–4, 356–7]. Wilcox, the first incumbent, was succeeded by Waugh, and the office fell into abeyance on the latter becoming Superintendent of the Great Trigonometrical Survey. In 1849 it was revived for Renny-Tailyour when he was called in to Dehra Dūn for general duties, and on his retirement in 1854 it passed to Strange [379].

On Strange's retirement Waugh made a detailed review of the qualifications of no fewer than six officers whom he considered fit for the post[1];

> All...have been trained...by myself, and are thoroughly conversant with the duties of the Department. ... They are capable of originating and carrying out any part of the operations, and conducting the difficult computations and abstruse mathematical investigations connected with the work without extraneous assistance, which unfortunately Major Strange was not. They are also fully competent to train up assistants. ... I consider Major Walker and Captain Montgomerie to be equally able and meritorious, but as Major Walker is senior both in military rank and length of survey service, I...recommend him for the appointment. ...
>
> It will be obvious...how painful it is to me to allude to an officer of Major Strange's practical merits in a deprecatory tone as regards his ignorance of mathematics and want of experience,

[1] Walker, Montgomerie, Nasmyth, Basevi, Hennessey, Robinson.

...but justice to others...obliges me to record their superiority [340, 382]. ... To the same...practical skill these officers add mathematical knowledge and survey talents of the highest order[1].

After Walker became Superintendent Trigonometrical Survey, Montgomerie held the post till his retirement when it finally fell into abeyance.

Markham wrote of the officers of the Great Trigonometrical Survey in 1870 ;

It is, and has been, a very noble band, that body of surveyors who have been trained, and have worked under Lambton, Everest, Waugh, and Walker. ... These men must combine the knowledge and habits of thought of a Cambridge wrangler with the energy, resource, and presence of mind of an explorer or a backwoodsman, and they must add to this the gallantry and devotion which inspire the leader of a forlorn hope[2].

There were, indeed, many who did not reach this very high standard. On the other hand there were many amongst the civil establishment who, though without the knowledge of mathematics and science desirable for the higher grades, yet had the devotion and high character that contributed so largely to the success of the Survey. Many of these did grand work in charge of field parties [405, 409, 415–8].

PROMOTION

Everest had established that on first appointment to the Great Trigonometrical Survey officers should be posted as 2nd Assistants, to draw staff salary @ Rs. 250 a month right through the year, and that their advancement to 1st Assistant on Rs. 618 should be made solely on the Surveyor General's recommendation that they were fit for an independent charge. As a general rule, such recommendation would be made after two years service, but both Everest and Waugh retained full liberty to vary this period exactly as they thought fit [IV, 352–3].

Du Vernet had joined the G.T.S. in September 1841, and in spite of his having had eight years service in Madras topographical surveys, Everest did not think his first two seasons work on the North Connecting series justified promotion. It was not until the end of May 1844 that Waugh recommended him ;

For the first two years the work performed by him was not in exact keeping with that on the other subordinate series. ... This arose chiefly from Captain Du Vernet's comparative inexperience, ... and in some measure from bad weather. ... His next season's work, however, was a decided improvement on the preceding two. He had...finished the Himalaya Longitudinal series, ... and the late Surveyor General...deemed Captain Du Vernet worthy of advancement to the post of 1st Assistant, and accordingly recommended his...preferment. ...

The fourth season, ... from 1st October 1843 to 16th April 1844, ... he has extended in a masterly style through a difficult country a series of principle triangles between...the series of Amua and the meridian of Karara, and...is entitled to every...encouragement. ... I beg...to add my recommendation...that Captain J. S. Du Vernet be advanced from 2nd to 1st Assistant...on the usual salary of Co.'s Rs. 618...per mensem in addition to his regimental pay and allowances[3].

In a later letter Waugh noted that conditions for promotion were

proved fitness to command a party of the Trigonometrical Survey—to observe skillfully—to perform the requisite computations—and to discharge all the duties appertaining to the grade of 1st Assistant. ... Such promotions have hitherto been made after periods of probation varying from 14 months to two years. ... The average period has been about 18 months.

He added a statement which showed the longest intervals between first appointment and promotion to 1st Assistant to be 4 years 2 months for Du Vernet and 2 years 10 months for Rivers, the shortest being those for James Walker, 4 months only—after 4½ years on the Peshāwar survey—and Montgomerie, 1 year 6 months.

He now recommended Herschell and Harry Thuillier for the step after 16 and 21 months service respectively, having "proved themseleves to possess all the qualifications necessary for success in the Great Trigonometrical Survey"[4].

Whilst Engineer officers were exempt from the regulation to revert to regimental duty on promotion to major, this regulation compelled the untimely with-

[1] DDn. 2 (57), SG. to Mil. Dept., 17-9-60. [2] Markham (146 ; 1st. edn., 124). [3] DDn. 452 (141–3), 30–5–44 ; sanctioned Mil. Dept. 14–6–44 (129). [4] DDn. 2 (182), 23–2–61 ; 25 (2), 8–3–61.

drawal from the Department of many valuable surveyors of other corps. When permitting Strange's retention in 1951 the Directors agreed

that it is necessary to the successful prosecution of the Great Trigonometrical Survey that the trained and highly qualified assistants employed in it should not be removed on promotion. Unless, therefore, their services are imperatively required for military duties, their continuance in their present employment has our sanction[1] [526, 533].

Though receiving a brevet majority in 1854, Strange's regimental promotion did not take place until 1859, when he assured the Surveyor General that his "interest in the profession, which has during twelve years engrossed my thoughts, ... continues undiminished[2]," but Waugh could no longer press for his retention ;

Of all the officers in the Department in...1851, Captain, now Major, Strange is the only one left, which will afford an idea of the very restricted...means at my disposal at that period. ... He is a good practical officer, and although his services of late years have...in some measure ...disappointed expectations, still he could continue to be usefully employed in the Trigonometrical Survey. ... I cannot now, however, conscientiously admit that his services are so important ...as to warrant...the standing rules of the service [being] set aside. ...

During 9 years...since Major Strange first urged me to apply for his special retention, several officers of brilliant talents and ability have been trained up. These officers...Maj. Walker, Capt. Montgomerie, Capt. Nasmyth, Lieut. Basevi, would fairly gain a step in the Department if the ordinary rules are enforced, and they would be deprived of this advantage if Major Strange's case is made special. Their claims, however, are stronger than his, for...[they] have pre-eminently distinguished themselves as Surveyors, and they all possess high mathematical qualifications. In these respects Major Strange is remarkably deficient [380–1]. ...

I cannot, therefore, fairly urge that Major Strange's removal on promotion would cause any inconvenience at this time[3].

Strange reverted to military duty at the close of field season 1859–60, and left India for good at the end of the year [151].

TRAINING

When Garforth and Reginald Walker first joined they were both sent to the Chendwar series under Logan before being given independent charge of a party. It had not been possible to give the Bombay officers a spell with the Bengal parties, but Everest had at different times called both Shortrede and Jacob to join him for a few months at Sironj [IV, 4, 73–4, 100, 359]. Rivers had only a few months under Jacob before taking over charge [IV, 74, 464].

In 1850 Waugh pressed for reinforcements ;

There are seven parties employed. ... To render these...not only fully efficient, but to provide against casualties, there should be seven 1st Assistants and three 2nd Assistants, or 10 effective officers in all. ... I have only six. ... Of these Captain Hill has been for some time ...inefficient from ill-health, and has now proceeded to sea on medical certificate for 2 years. ... [He] expects his regimental majority...within the period of his sick leave, by which event he would be removed from the Department [381–2]. Captain Renny-Tailyour...will...resign the service in 2½ years, whilst Lieut. Rivers has some intention of taking his furlough in a short time. Captains Du Vernet and Strange also stand high for regimental promotion. ...

The time occupied in acquiring a competent knowledge of the instruments, the methods of observation and mathematical calculation, occupies generally not less than two years. ... It appears...indispensable that 2 young Engineer officers at least should...be attached to the Department as 2nd Assistants [380]. ... Unless properly trained before they are placed in charge the work is never satisfactorily performed.

A rigorous training is indispensable at the outset. ... Widely dispersed as the surveys are, and remote from constant supervision, ... innovations would creep in, and the character of the work become compromised [IV, 92]. ... Due provision should be made for...vacancies instead of waiting till they occur [380][4].

He pressed again the following year ;

In Colonel Everest's time all the operations were concentrated close together, with one exception, and that exception, the Parasnath series, turned out a complete failure [IV, 59–61].

[1] CD. to B. Mil., 3–3–52 (5). [2] DDn. 697 (116), 21–2–60. [3] DDn. 2 (9), to Mil. Dept., 8–3–60.
[4] *PR.* (17). DDn. 542 (18, 37, 153); SG. to Mil. Dept., 6–5/20–8–/20–10–50 (para 66).

... Officers can only be trained in a good system by working with well-managed series, and under able leaders. ... The great success which has attended my administration...has arisen from...this rule—...not to entrust any officer with the charge of a series until satisfied of his fitness, because every failure can be traced to this source[1] [390].

The Government of India told the Directors they had no officers to spare but were asked to meet the Surveyor General's demand[2] and during 1851 and 1852 Tennant, Nasmyth, and Montgomerie were appointed, whilst permission was obtained to retain the services of Strange [382].

Tennant worked under Strange nearly two years making

himself thoroughly master of the usual recess duties ; ... computations—cleaning, repairing, and adjusting instrumental apparatus and other preparations for the field—office business. You should give him [writes Waugh] such a share in the various computations as will conduce to his becoming acquainted with every part of the work. Expertness in...computations is even more important than field duties, inasmuch as excellence in the former is rarer than in the latter.

The ensuing field season will enable Lieutenant Tennant to master the details of field duty, ... and I hope...he may gain a thorough insight into every part of the work and become imbued with the most scrupulous notions of refinement. ... As soon as you can report that this officer has acquired a thorough knowledge of these duties, I shall make arrangements for putting him in a position in which his talents and knowledge may have full scope[3].

Montgomerie had a year with Logan on the Rahun series, and then had the exceptional advantage of spending several months with the Surveyor General himself on the measurement of the Chach and Karāchi base-lines [42–4].

In an appreciation of his officers Waugh writes in 1859 ;

I have had a succession of officers of all ranks and of all branches of the service in the three armies of India, as well as the Royal army [Austen], under my orders, and...it is rare for any officer to succeed in any eminent degree unless he joins at an early age with sufficient elementary knowledge of mathematics and military drawing, a marked aptitude for the profession, and a determination to devote all his energies to one object. ...

At the Chuch base-line I had no experienced officers to assist me except Mr. Logan who was very ill and died shortly after. I had to train every officer employed at that base-line, as well as at Kurrachee, and if any accident had happened to disable me, those difficult manipulations must either have been postponed or entrusted to inexperienced hands. ... I took advantage of...these bases to instruct all the officers of the Trigonometrical Survey then available, knowing that some years might elapse before another base would be measured. ...

An officer when first appointed has everything to learn, and for the first year at least is rather a hindrance than an assistance. Gradually as he learns the practical duties and masters theoretical principles he become useful, and after 2 or 3 years he is able to act independently. Year by year, however, he improves. ... An officer of the Trigonometrical Survey cannot be considered fully experienced much under 10 years service. ... The loss of an experienced officer deprives the State of all that has been expended on his training, not to mention the heart-breaking task of constantly teaching new hands. ...

The chief...apprehension...has been the loss of experienced officers from retirements holding out higher inducements. That competition falls peculiarly hard on old departments, with salaries fixed in ancient times, and...obliged...to train their own hands from the beginning. I would...most earnestly submit that...the Department should not be deprived of its most experienced officers, trained with so much care[4] [399, 408].

TOPOGRAPHICAL SURVEYS : MADRAS & BURMA

The only regular topographical survey in progress when Waugh took office was the Hyderābād survey under Henry Morland of Madras infantry. The Salem and Nellore surveys were in process of being wound up, and the Ganjam survey was in suspense for lack of a suitable officer [IV, 248–50 ; V, 167].

In 1844 a Madras Engineer officer, John Ouchterlony, was appointed to make a revenue survey in the Nīlgiri Hills, and for the geographical part of his survey was

[1] DDn. 542 (250), 28–8–51. [2] DDn. 541 (321), CD. to B., 2–4–51 (49–50). [3] DDn. 709 (1), 26–7–52. [4] DDn. 643 (352), to Mil. Dept., 3–11–59.

placed under the professional direction of the Surveyor General. He was withdrawn for engineer duties after completing a topographical map on the half-inch scale, and the Surveyor General recorded that " the difficulty of obtaining the services of Engineer officers for the Survey Department has always been very great, and the withdrawal of an officer of Captain Ouchterlony's superior talents and energy is a great loss[1] " [179–80].

The officers who followed each other in charge of the Pegu Survey in Burma were all appointed by the Army Commander or Chief Commissioner at Rangoon. Williams, Trevor, and Edgecome were Engineers, and Fitzroy came from Artillery. It was not until 1863 that the latter was placed under the orders of the Surveyor General [195–9].

HYDERĀBĀD

Morland reverted to military duty in March 1848 after promotion to Major, and the Madras Government then appointed Bt. Major John Brown in his place without any reference to the Surveyor General. He was a cavalry officer with no knowledge of survey, and no promise of acquiring such knowledge. Waugh was naturally disturbed at such an appointment, more especially as the party was so remote from the rest of the Department ;

In consequence of no assistant officer having been appointed for several years to the Madras surveys, there was no qualified officer to take charge on the removal of Major Morland, ... and...Mr. Chamarett, the senior assistant who...was the main prop of that survey, having died not long afterwards, the efficiency and acquired skill of the party was in danger [428]. ...

Brevet-Major Brown...never having been employed in the Survey Department or analagous duty before, nor having received any...education for it, cannot fairly be expected, at his age, to become a very skilful surveyor. He is no doubt willing to learn, ... but there is no one to teach him except his own sub-assistants whom it is his duty to guide and control. ...

I have consulted Captain Du Vernet because he formerly held charge of the Hyderabad Survey, and in his time the progress made was very satisfactory and the execution superior [IV, 256–7 ; V, 177–8]. He concurs...regarding the necessity of appointing assistant officers to be selected with care and thoroughly trained, first in the Trigonometrical Survey and afterwards in detail duties [382]. ...

Captain Du Vernet agrees with me that an assistant officer will be required for each party... to prevent...these surveys from being paralysed by casualties. ... I would recommend that two young unmarried subalterns of about four years standing should be chosen, of undoubted taste for drawing and good mathematical attainments. ... If a proper standard...be...adhered to, I see no difficulty in finding able officers...who would do ample justice to the work[2].

The posting and "training of two well-educated officers of the Madras Army with...the surveying parties" was approved in principle [III, 329], but could not be effected, and the following year Waugh asked for the suspension of the survey ;

With regard to Major Brown's professional qualifications, I...felt anxiety for the future success of this survey on account of his deficiency in elementary education for survey duties. ... He has invariably exerted himself to the best of his abilities, and shews no lack of zeal for the public service, but a person at his time of life and high standing in the army is not capable of acquiring...professional skill himself. ...

There are at present no qualified officers available to assume immediate charge of the Hyderabad party, and the paucity of officers with the Great Trigonometrical Survey...precludes my recommending that an officer should be detached from that Department as a temporary measure. ... Considering the low standard of Major Brown's professional qualifications, and the impracticability of carrying on...satisfactorily in the present disturbed state of the country without greater tact...on the part of the officer in charge, I...recommend that the Hyderabad survey should be suspended for two years[3].

Brown reverted to his military unit in January 1851, and the survey was suspended until restarted in 1855 under James Mulheran [178, 416].

[1] DDn. 549 (63), SG.'s Report for 1849–52, 9–9–53. [2] DDn. 462 (321–2), SG. to Mil. Dept., 13–6–49. [3] DDn. 549 (4), to Mil. Dept., 17–7–50.

After Hill's departure on sick leave in 1841 the Ganjam survey lay in abeyance till 1844 when John Halpin, who had been surveying routes on the western borders towards Patna State, was placed under the Surveyor General's orders with two sub-assistants [167]. Finding after two seasons that he had but little survey knowledge Waugh suggested his temporary attachment to a Bengal party for instruction [35].

On the abolition of the...Deputy Surveyor General at Madras, ... officers appear to have been appointed from time to time...to charge of surveys...possessing no previous experience, deprived of all chance of acquiring instruction, and...as much injured in a professional point of view...as the public service was injured from their want of proficiency. ...

I have drawn up a very detailed book of instructions on the...practice of surveying [281–2], ... and thus spared the necessity of calling officers to headquarters. ... Still, ... every officer learns more in 6 months from actually witnessing work in the field than he could ever acquire in 6 years by himself, although aided by all the books ever written. ...

All the Madras surveys rest on a trigonometrical basis...but this basis, if carried on unsystematically, ... loses half its value. ... With the view of imparting a higher character to the survey in Ganjam, ... I...recommend...ordering Captain Halpin to join headquarters as a temporary arrangement. ... Captain Halpin appears to be intelligent and possessed of every preliminary qualification, but he has not had the advantage of being trained. Bengal is at present the only place where a surveyor can learn his duty properly[1].

Halpin, therefore, worked with Du Vernet on the North-West Himālaya party throughout season 1847–8, but unfortunately died soon after his return to Ganjam. Saxton, whom the Madras Government appointed to succeed him, again had no survey knowledge, and the Surveyor General attached him straight away to the East Coast series for training under Hill, leaving the Ganjam party to continue under the senior sub-assistant [168]. Hill was directed

first to instruct Lieutenant Saxton in the use of the theodolites of 12 inches and 7 inches diameter—to observe correctly—read off the verniers—change zero—deduce the angles from the readings—and draw out the means on proper principles—also to observe vertical angles correctly—and deduce the means. ... I should wish him to be instructed in the use of the large theodolite to the end that he may acquire higher notions of accuracy, and if he discovers any genius for geodetical pursuits, I may have an opportunity of fostering his talents. ...

It will be proper to instruct him in...route surveying on accurate principles, and in the use of the planetable in which...he should acquire sufficient skill...to instruct others, as well as control...his assistants. ... [He] should take a part in each kind of computation.

Having...held charge of the Ganjam survey yourself, you are...acquainted with the acquirements necessary...that the work may be fit for incorporation into the Atlas, and never require to be done over again [281]. ... The triangulation...should be conducted on more systematic and accurate principles than heretofore, ... and...the officer in charge should...subject the planetable sections to a rigid examination, and direct...the improvement of the drawing[2] [170–1, 176].

Saxton joined the East Coast series on 11th July 1849, and after satisfactory reports from Hill took over charge of the Ganjam party during the following May [168], the Surveyor General reminding him that he expected

much greater results than from your predecessors. I look to you to raise the character of the survey to a higher standard and introduce more systematic and energetic performance of duty. The system which has hitherto prevailed can no longer be tolerated[3].

In September 1853, the Surveyor General recommended him for an increase of salary, the Madras salary for an Assistant Surveyor General—as the designation stood in that presidency [III, 317 ; IV, 361 ; V, 386]—being Rs. 350 a month as compared with the Rs. 618 of the Trigonometrical Survey [III, 320, 350–1] ;

Success entirely depends on the health and constancy of Captain Saxton whom it would be very difficult to replace. This is one of the great evils of the paucity of officers with the Survey Department. ... The duty must be reckoned one of considerable hazard. I am anxious therefore, to attach Captain Saxton more completely to the work, ... and...recommend that he should receive a personal allowance of Rs. 100. As Assistant Surveyor General his salary is Rs. 350 per mensem, and would...be raised to Rs. 450 which, considering the nature of the duties and the success he has achieved will not be reckoned excessive [398–9][4].

[1] DDn. 462 (58–60), SG. to Mil. Dept., 24–9–46. [2] DDn. 493 (199), SG. to Hill, 18–5–49. [3] DDn. 588 (27), 29–3–50. [4] DDn. 549 (63), SG. to Mil. Dept., 19–9–53.

He writes privately to Saxton in May 1854, promising to recommend the appointment of his nephew Depree [171] ;

I think he would be a most desirable acquisition to the Department, and you sadly want an assistant. ... There is always difficulty in getting Artillery officers, as at Army Headquarters they...plead the want of them. ... The gunners naturally complain much of this impediment to their prospects. ... No men are better qualified...for survey employ [390]. ...

With reference to your wish to visit Pooree and take a portion of your establishment there, ... the best plan is to allow an officer of your zeal and attachment to the work to act as he may find most beneficial for the public service, and convenient for himself and party. ... You can reside anywhere that may be most suitable for the work ; ... the success of your survey depends on yourself and party being in active and vigorous health [367]. ...

I recommended in my general report...that your pay should be increased, a proposal which has gone on to the Court with the support of Government. I am very glad to hear that you have passed in Ooriah. This cannot fail to increase your means of usefulness[1].

In recommending Depree's appointment Waugh pressed the importance of the survey of the Tributary Mehals and adjoining districts, the scene of the Merriah operations [IV, 254, 456 ; V, 170]. The whole tract from Cuttack to the Nagpore province and south to the Kistna remains to be surveyed, and is known to be rich in minerals and other products, while the climate is so insalubrious that it is running a great risk to leave...the undertaking dependent on the health of a single individual.

There is not one of the subordinates fit to take charge if Captain Saxton lost his health. ... The progress of the survey formerly suffered very much from casualties of this kind [167–8]. ... I am naturally anxious that it should not lapse into its former languishing condition for want of well trained and energetic leaders[2].

Depree joined in October 1854 and took over charge when Saxton took furlough in December 1855. In view of his youth and comparative inexperience the Surveyor General put the party under the general supervision of Strange who had just taken over charge of the East Coast series, and was also recessing at Cuttack. He was anxious to avoid hurting Depree's feelings ;

It will be a great advantage to you to be able to claim Major Strange's advice. ... Segregation and a want of communion with kindred spirits is always a disadvantage. ... He is well acquainted with our departmental traditions, forms, and usages, and is in possession my views generally on all professional subjects. ... I have every confidence in yourself. ...

Your uncle has done so much towards the improvement of the Ganjam survey establishment that I need only recommend you to tread in his footsteps and persevere in the path of reform and improvement. We must be satisfied with nothing short of perfection. ... Look on me as a Father—Let me know your wishes[3].

Strange was favourably impressed and reported that he had been in constant communication with Lieut. Depree, and have held with him frequent and lengthened professional discussions. ... I have seen him handle instruments of various sizes including the 24-inch theodolite under my charge. I think him peculiarly well qualified for his profession. He has a light hand and excellent eye, steady nerves. Besides these valuable physical gifts he is remarkably patient and painstaking ; has very clear perceptions, and a sound judgement ; fully appreciates refinement, and is most anxious to master the art of surveying[4].

Waugh was still not really happy about the Orissa work, and writes to Thuillier whilst Saxton was on furlough ;

Depree is by rights an Assistant Surveyor General. That is the old term of the Madras Presidency [III, 317 ; IV, 361 ; V, 385], the organization having been military like the Adjutant General's and Quartermaster General's Departments. I like the term myself. It is soldier-like, and in these days of uncovenanted topsy-turvyism that is some advantage. In former days the Survey Department of Madras was as superior to Bengal as the latter presidency was superior to the "benighted" on all other points.

There is a mess about that survey now. Saxton was a patronage man, and is not worth more than he gets. Depree is his nephew, selected by Saxton to be his assistant. ... Possibly Depree may be worth more ; it remains to be seen. ... Under Saxton the work remained mediocre, but we may expect great things from Depree[5].

During 1856 the party was expanded and split into two independent parties, of which Saxton and Depree held charge turn and turn about as one or the other

[1] Family letters, SG. to Saxton, 26–5–54. [2] DDn. 547 (274), SG. to Mil. Dept., 29–9–54. [3] DDn. 691 (33), 10–4–56. [4] DDn. 697 (119), to SG., 5–7–56. [5] sg. fd. corr., 26–9–56.

went on furlough, when civil assistants, Dyer or Nicolson, were brought in for the second party. From 1860, Depree took his party into Chota Nāgpur whilst Saxton worked the other southwards through the wild border country lying between Madras Presidency and the Central Provinces till he retired in 1873. Depree spent all his service with topographical surveys, finishing as Surveyor General from 1884.

PUNJAB

From 1847 Robinson was employed on the survey of Hazāra by the Civil administration at Lahore and from 1849 James Walker was deputed to a military survey of Peshāwar district beyond the Indus. Neither had any previous experience of such extensive surveys, but though they measured the roughest of bases and observed the simplest triangulation, the maps they produced were of the utmost value for military and administrative purposes. They were later connected to the principal triangulation.

In April 1851, Walker was placed under the orders of the Surveyor General, and his work connected up with the North-Western series. In 1853 he was appointed to the Trigonometrical Survey [52], in which he greatly distinguished himself [340–1, 380].

Robinson was placed under the Surveyor General's orders in 1850 for topographical survey of the Jhelum and Rawalpindi districts[1]. " I am...anxious " writes Waugh, " that this survey should be of a superior order, and fully expect that the map...will be one of the best ever executed in India [210][2]". Supplied with a stream of promising young assistants, Robinson fully justified his selection. He became a first-class triangulator, planetabler, and draughtsman, and his topographical survey and mapping became the ruling guide for the Department.

As the survey drew to a close he became anxious about his future promotion. His contemporaries and juniors in the corps of Engineers were being advanced to administrative posts in the Public Works Department whereas there were no similar posts to which he could rise in the Survey. He was not qualified as geodesist for advancement in the Great Trigonometrical Survey ;

The Lieutenant Governor of the Punjab has in very handsome terms offered me an appointment in the Canal Department which is not only superior in emoluments to the appointment I now hold, but also affords the prospect of...speedy advancement.

I am very loth to quit the Survey Department because I believe that thirteen years practical surveying...have given me that knowledge of the subject which ought to render my services... more valuable than those of a less experienced officer. At the same time it appears...almost suicidal...to remain on my present footing[3].

Waugh would not recommend his release before his maps were completed, but suggested that he was worthy of some special increase of salary ;

I should be extremely sorry to stand in the way of Captain Robinson's prospects, but... point out the injury to my Department...by his removal at this time. ... Captain Robinson is one of the few officers who has been instructed in my system of topographical surveying, and he has carried out my instructions rigorously. ...

[He] is now receiving the staff salary of Rs. 618 per mensem, appertaining to a...1st Assistant Great Trigonometrical Survey. This is a fixed allowance of very old standing [I : 277 ; II, 326 ; IV, 365], and has hitherto given every satisfaction. ... Since the re-organization of the Department of Public Works, however, the comparative advantage...is reversed. The members of the Public Works Department...now receive travelling allowances, ... while the surveyors in every grade, though marching for the greater part of the year, pay their own travelling expenses. ... The Public Works now offers so many prizes in every grade...that it afford a better field than the Survey Department. ... If he [Robinson] had originally joined the Public Works...he might now...expect to be Superintending Engineer[4].

The very day before sailing from India Waugh suggested that Robinson might be made Superintendent of Topographical Surveys[5] and, writes Robinson;

[1] including the present Attock District. [2] DDn. 542 (332), to Mil. Dept., 20–9–52. [3] DDn. 714 (151), to SG., 30–5–59. [4] DDn. 549 (194), to Mil. Dept., 7–6–59. [5] DDn. 2 (183), 12–3–61.

I have refused repeatedly offers of better appointments elsewhere, the last in February 1860 which I was on the point of accepting, when Sir Andrew Waugh sent his personal assistant, Mr. J. B. N. Hennessey, to beg me to remain in the Survey, and to promise that...he would endeavour to obtain for me the allowances of a Superintending Engineer. ... Had I accepted that appointment my emoluments would have been doubled.

At school, at Addiscombe, and in the peculiar kind of survey I have been employed on for the last fourteen years, I have always been the first among my competitors.

He protested at Walker's promotion, his junior in military rank;

I was first mathematician and first Engineer cadet of the term which left Addiscombe in June 1843, and after sharing in the Sutledge campaign [1845–6] I was employed in surveying the Jammoo frontier under the Boundary Commissioner. ... With the exception of the short interval of the Punjab campaign, throughout which I acted as an extra assistant to the Resident of Lahore, ... I have been continuously employed in surveying ever since. ... Major Walker, the present Superintendent G.T.S. being a cadet of 1844.

As compared with other Engineer officers, all of those senior to me, and at least fifteen of my juniors, receive salaries equivalent to, or superior to, that of a Superintending Engineer. ...

The late Surveyor General...always considered topographical surveying the most difficult of the various kinds of surveying, requiring a special and rare talent, much cultivation, and constant practice. Although I have neglected no opportunity of adding practical knowledge to theoretical acquirement by observing with the larger instruments, and attendance at the Chuch base-line, I am superseded because...I have had less opportunity of acquiring this practical knowledge than my juniors. ... I may remain in the Survey Department till the end of my career, superseded from time to time by Trigonometrical Surveyors[1].

He was strongly backed by Thuillier, and in August 1861, Government granted him a special allowance of Rs. 800 p.m., equivalent to that of Superintending Engineer, whilst holding charge of the Central India topographical survey[2]. On Walker taking furlough in 1863 he officiated as Superintendent Trigonometrical Surveys till 1865, when he was appointed to act as Director of the Telegraph Department, being confirmed in that post the following year.

KASHMIR

The first consideration in the survey of Kashmir was the chain of principal triangles with its secondary and minor series, for which Montgomerie's assistants were all skilled members of the G.T.S., or young engineer officers under training. At the end of the first season the Surveyor General asked for young military officers of the Quartermaster General's Department to take up the detail work,

sketching with care and minuteness hill-ground of very difficult and diversified character on the basis of accurate triangulation. ... I could find employment of this kind for any number of youg officers who can draw, not exceeding 4 at present. ... It would be necessary to put them for the time being entirely under my orders[3].

The Quartermaster General offered four of his officers, of whom Lumsden, Allgood, and Charles Johnson, joined at Srinagar in May 1856 to take up ½-inch planetable survey in the Kashmir valley. They were to be available "every hot weather" so long as there were no urgent military calls[4].

Lieutenant Montgomerie trained Captain Lumsden, Allgood, and Johnson in the use of the planetable. ... Notwithstanding the difficulty of the ground, the unusually heavy rains, and the sickness of Captain Johnson, these officers executed 3,200 square miles...in good style. A greater area would have been completed if...Captains Lumsden and Allgood had not been urgently required in their own Department [225–6][5].

Unfortunately so far as the survey was concerned the value of this training was lost as none of these officers could be released for a second season. However, in January 1857 an application was received from Peshāwar from "Lieut. H. H. Austen of H.M.'s 24th Regiment...requesting to be employed on the topographical part of the Cashmere Trigonometrical Series". He had passed "in the languages and in the trigonometry, surveying, plan-drawing, etc., at the R.M. College, Sandhurst".

[1] DDn. 42 (2), & 714 (229), to SG, Thuillier, 8–4–61. [2] DDn. 6 (149), Mil. Dept., 14–8–61.
[3] DDn. 645 (174), 12–12–55. [4] DDn. 644 (364), 21–1–56. [5] DDn. 692 (271), TGM to SG., 26–3–57.

Applications were received from other officers, and Austen of British infantry, and Melville and Murray of Bengal, reported to Montgomere during May and June. Again Montgomerie had to give elementary instruction in planetabling [227, 229].

This time the Survey was allowed to retain the service of all three officers after the close of the field season, and they were deputed in February 1858 to take up work in the low country round Jammu which was free of snow [230]. All three made excellent progress, and the Surveyor General obtained approval for their permanent posting to the survey from 22nd February 1858.

Lieutenant Austen is senior to Lieutenants Melville and Murray and a most accomplished field draftsman. He has given the greatest satisfaction. ... I trust therefore that his permanent appointment and promotion may be sanctioned from the same date as Lieutenants Melville and Murray in order that he may retain his proper standing in this department[1].

In September 1858, Murray was transferred to Robinson's party in the Punjab for the cold weather months whilst Melville and Austen worked on through the Jammu area. In January the Surveyor General reported that as Austen had recently been promoted Captain he would be released for return to England ;

He is at present employed in the survey of Kashmir and having been trained to...that work his departure will be a great loss. ... He is at present engaged in a portion...which it is very important should be completed before he leaves, and which...may be finished in two or three months time. ... Captain H. Godwin Austen...has distinguished himself greatly in the Kashmir survey by his zeal, industry, and ability. ... If he should return to India it will be a great advantage to the Survey Department that he should be reappointed to it[2].

In April 1859, therefore, Austen was released from the survey and proceeded home[3].

Of these three officers the Surveyor General now reported ;

The Government of India were pleased...to sanction the appointment of 4 or 6 young officers as Topographical Assistants to the G.T. Survey. It was a difficult matter to select gentlemen with sufficient previous knowledge of military drawing and mathematics...on the moderate...staff salary proposed [399]. Three officers only with the necessary qualifications were found, viz., Captain H. H. Godwin Austen, H.M. 24th Foot—Lieutenant A. B. Melville, 67th N.I., and Ensign W. G. Murray, 24th N.I. The first had been educated at Sandhurst—the next at Roorkee—and the third at Addiscombe.

These officers speedily learned their duty and did excellent service. Captain Godwin Austen exhibited special talent...and Lieutenant Melville's work was also very good. Both these officers proved themselves indefatigable mountaineers. ... Lieutenant Murray also... proved himself a useful surveyor ; the great exertion however of climbing in these stupendous mountains proved uncongenial to Lieutenant Murray's constitution and I have...transferred him at his own request to the Jhelum and Rawalpindee survey[4].

Though sanction was given for the posting of four more Topographical Assistants no suitable officers could be released from military duty. A year later, however, Austen returned to India, and was re-appointed to Kashmir[5], and in 1861, when his battalion left India, he obtained permission to remain behind and was transferred to the newly formed Staff Corps for employment with the Survey Department.

In 1862 Murray, who had accompanied Robinson's party to Central India and had frequently held temporary charge, was promoted to independent charge of the Rewah survey. Austen and Melville protested at being passed over by an officer junior in military rank, and were supported by Montgomerie ;

Early in 1857, Lt. Austen, Lt. Melville, and Ensign Murray were appointed as probationary assistants in the Topographical Branch of the G.T. Survey, their names standing in General Orders as here given, being that of their Army ranks. ... During 1858 Lt. Murray pleaded that the work in the mountains was too hard for him, ... more especially in the higher ground, [and] was at the end of 1858 transferred to Captain Robinson's party. ... Up to the end of 1858 these 3 officers were working in the same party, and...there was certainly no evidence... that Lt. Murray had in any way outstripped the other two. ... Captain Godwin Austen...had —on his return to India—his position as senior...specially guaranteed by Government[6].

At the beginning of 1861...the Survey Department was put upon a different footing which ended in Captain Austen and Lt. Melville being left under the Superintendent G.T. Survey,

[1] DDn. 643 (247), to Mil. Dept., 23–8–58. [2] DDn. 715 (450), to AG. HM. Forces in India, 25–1–59. [3] Go. 12–4–59. [4] DDn. 643 (291), to Mil. Dept., 28–5–59. [5] DDn. 642 (440), Mil. Dept., 21–5–60. [6] Mil. Sec. in letter 642A, 21–5–60.

whilst Lt. Murray was placed under the Surveyor General, ... Superintendent of...Topographical Surveys [340]; ... all three...still employed on topographical work. ... Government having sanctioned the increase of the topographical surveys, ... the first extra charge of a new party was given to Lt. Murray, whilst his seniors...got no promotion whatever[1].

Austen and Melville were promoted to charges shortly after.

In discussing the general question of selecting officers for charge of a topographical party, Waugh insisted on the necessity of employing no officers

who have not been trained in the system of my predecessor and myself. It may be contended that officers without practical experience have...succeeded. ... I have no hesitation in answering that for one such success several failures might be quoted [382–3]. ...

The history of the survey of India shews that distinguished success has not been confined to any one branch of the army in particular. The Artillery, Engineers, Cavalry, and Infantry, can all adduce honourable names who have achieved distinction in the department of Survey. ... But without mathematical knowledge...the early promise has never been realized ; that science forms the basis of the art of surveying. ... Hence, if officers are required in a hurry, ... the best guarantee for success is to choose young military Engineers. The extent and variety of their previous education, more particularly in mathematics, ... is of great value. ... The education of Artillery officers also renders them peculiarly eligible in the next degree[2] [IV, 357 ; V, 386].

DISPUTES & CENSURE : SHORTREDE

Throughout his term of office Waugh endeavoured to maintain the professional work of the Great Trigonometrical Survey at the highest standard though a few field parties were so distant that he was never able to reach them. To make personal acquaintance with his Bombay officers he was sometimes able to summon them to his own camp, but control was mostly exercised through lengthy letters, frequently repeated to one new officer after another. Eventually the more important of these instructions were put into print [117, 281–2].

From time to time instructions were set aside and in a few cases actually challenged. Waugh would then pour out long explanations of elementary principles, hoping to convince the wayward by reasoned arguments. He was himself the acme of patience, and would extend argument and dispute when sharp orders might have been more appropriate [344–5, 542]. Only occasionally was his patience exhausted and replaced by rebuke and command. He writes in 1855 ;

It cannot reasonably be expected that all men should be equally perfect and the Surveyor General who makes it a rule to do his duty fearlessly...with an even hand to all must...give offence to some. ... It has been my lot...to have to perform a few (a very few) painful duties. ... I have never...acted hastily without careful consideration. ...

That I have no natural disposition to be vindictive or harsh...may...be proved by...the fact that when I was a corporal at Addiscombe I never gave a punishment yet it was publicly acknowledged...on 13th December 1827 that I had kept my Division in as good order as anyone. ...

Last year on my way though the Punjab to Sind I had been misrepresented in the Lahore Chronicle as a kind of imperious, over-bearing, savage of a Bengal Tiger, and a stranger who had seen this...was much amused on meeting me to find I had been so...misrepresented[3].

Shortrede had always been a difficult officer to handle for, in spite of his outstanding talents as mathematician, he had never grasped the need for meticulous detail in geodetic work, nor even the general principles which Everest had laid down. He was lacking in physical energy and impatient of criticism [IV, 466 ; V, 115]. He was now in charge of the Karara series, where progress for the last three years had been much below average. Waugh had never met him, but knew that Everest had a poor opinion of his work. He now had reason to complain of an official letter in which Shortrede had written discourteously of Everest[4], and found

that he was not working efficiently, but was, in fact, idling. I accordingly addressed to him a letter...entreating him...to exert himself...to enable me to make a favourable report. ... Major

[1] DDn. 51 (98), TGM. to STS., 2–8–63. [2] DDn. 547 (363), SG. to AGG. GI., 30–6–55. [3] DDn. 665 (133), to DSG., Nov. 1855. [4] DDn. 491 (43–6, 54), SG. to Shortrede, 18–5–44 ; 520 (57), Shortrede's reply, 5–6 & 15–6–44.

Shortrede's previous inefficiency was not a matter in question. It had been reported by Col. Everest. ... Notwithstanding this warning his work still languished, and...up to 1st September [1844] he had not made efficient progress [11, 101]. I again addressed him the letter of 24th September 1844, ... and gave him every opportunity of vindication[1].

Government accepted Waugh's recommendation that Shortrede should revert to his province, Bombay, and he then took furlough. After his return to India he was posted to revenue surveys in the Punjab [270–4, 396]. Four years later he protested strongly against his selection for transfer to Sind, and complained to Thuillier of the way he had been removed from the Trigonometrical Survey in 1845 ;

It is impossible to look on my removal [to Sind] otherwise than as an indication that I am considered to be the surveyor whose services can best be dispensed with, as the least valuable and efficient. ... Such is the only light in which I can view it. ... Ten years ago I was removed...at the recommendation of the Surveyor General for alleged inefficiency, following up a train laid some years before by his predecessor[2].

Waugh was indignant and told the full story of Shortrede's earlier failure[3] ;

His success as a Revenue Surveyor, ... if it is a fact, would be no proof...that he was also efficient in the Trigonometrical Survey. ... The man in charge of a series of the G.T. Survey does nearly all the final work with his own hands. .. His assistants...may help him in preparatory duties and in computing against him, but he himself ought to be a good mathematician—a good observer—a good engineer—a good instrument maker—and he must be strong, healthy, and active, capable of undergoing great labour and exposure, and up to night work. That is why so few do succeed in the Trigonometrical Survey.

Everyone has borne testimony...that Major Shortrede had a competent knowledge of theory, but no energy or physical qualities for going through hard field duty. ...

Any man who understands theory, and can keep a well organized establishment at work may succeed as a Revenue Surveyor. ... Major Wroughton assured me that after the new system of Revenue Survey was introduced [IV, 212–4], he never touched an instrument or personally took any part in the work—that he had enough to do to pay wages, distribute work, look after the people, and physic them when they got sick [IV, 476].

He refuted the suggestion that as Surveyor General he had "no business to interfere in the Revenue Survey" for there were definite orders from the Court of Directors [338, 349], and he had, moreover, been asked by the Chief Commissioner to recommend a surveyor for Sind, and had nominated Shortrede as being a Bombay officer [277].

I viewed it entirely as an abstract question wherein the pieces were so many chessmen. Major Shortrede was to me no more nor less than the letter S. ... The Chief Commissioner... was...desirous to have the survey of his province commenced. Major Shortrede...knew the Bombay Presidency and the Bombay revenue system [IV, 236, 465]. Are these plain, honest, and weighty public reasons, or are they not ? ...

Major Shortrede...makes it entirely a personal question. ... He considers Sind a penal settlement, and lays claim from length of service to indulgent exemption from...going there. ... If Major Shortrede has a dislike to return to his own Presidency, or to Sind in particular, he would be a very unfit man to send. ... But, I protest against Sind being denounced as a penal settlement, or to any surveyor objecting to go there, or making any stipulation about going anywhere [IV, 389]. ... The whole of last season I was employed in Sind myself, and had 2½ parties of the Trigonometrical Survey engaged...on the base-line [43–4]. I have had no grumbling, no difficulties, and no objections [43, 452].

When my opinion is asked, I have right to say what I honestly think, and I will not allow any surveyor...to insult me by imputing unworthy motives, or to question my right of control over the whole Department[4].

An account of the storm over Himālayan attraction is given elsewhere [133–6].

RIVERS

Rivers, of the Bombay Engineers, had joined the Bombay triangulation party only a few months before taking over charge on Jacob's departure, and worked for the next six years without any personal contact with other officers of the G.T.S. His

[1] DDn. 665 (133), SG. to DSG., Nov. 1855. [2] DDn. 661 (115), to DSG., 18–8–55. [3] letter of 33 paras. [4] DDn. 665 (133), SG. to DSG., Nov. 1855.

theodolite had never been a high-class instrument and fell into serious disorder during 1848 [56, 156]. As it could not at once be replaced Waugh directed him to join up with his party for work on the Great Longitudinal series under Renny in order that he might learn something of Troughton's 3-foot theodolite, and benefit by working with the most experienced observer of the Department. He was further directed to take his party into recess with Renny at Nimach [38].

Rivers was extremely hurt at being thus directed to remain attached to

[Renny's] camp with no employment but in the performance of duties usually performed by sub-assistants. ... This prospect is one promising little interest to me, and implies a want of confidence, ... and points to but one course for me, ... of tendering my resignation. ... Judging from several of your letters...it would appear...necessary to inform me of several matters which, if I was ignorant of, I should never have been a candidate for the Department. ... I shall never join that appreciation of extreme detail...now considered requisite, ... indispensable doubtless in undertakings like arcs of meridian, but which...I consider merely amusing speculations to philosphers, and as gratifying to...those who conduct them. ...

I...own to a want of mechanical skill...to work with an instrument that may have got out of order, or to repair any accident beyond the simplest. ... I therefore propose proceeding to cantonments at Mhow to work up my arrears, and when that is completed to hand over the whole, or receive any other instructions[1].

Waugh made lengthy reply[2] [344–5] explaining the value of taking part in such an important operation as the Great Longitudinal series, and the practical importance of minute detail, and the maintenance of uniformity throughout the Department [115, 122]. ' Attachment to Renny's party was

advantageous to the service and yourself but, when in addition to this the wildness of your observations is recollected, and...the derangement of your theodolite, the measure will appear still more...expedient. In fact...I could not let you go on with an instrument unfit for use, and if you had not joined Captain Renny you must have sat still with your arms folded. ...

It is very easy for one gentleman to assert that a system is too accurate, and another assert the reverse. ... At the very time you were carrying on the South Konkan series [55] and observing angles on 3 changes of zero, or every 20° of the limb of a 15-inch theodolite, Captain Shortrede was observing on 12 changes on every 5° of the limb of an 18-inch theolodite, both...being unauthorized deviations, in contrary directions, from a departmental regulation [114–6]. ...

You seem to think it is a new thing for two parties to meet and canton together, but you are mistaken. It is the regular rule of the Department that as many parties as practicable should canton together for the sake of maintaining uniformity. ... Uniformity in a large Department is the soul of business and must be maintained [122, 370]. ...

Your instrument being out of order, ... no more final work can be executed with it in its present state. ... I was not without hope that Captain Strange might have succeeded in putting it into efficient order. ... This was one reason inter alia that I wished you to canton at Nimach with Captain Renny. Your proceeding to Indore is, therefore, not only a step taken in violation of my wishes, ... but very embarrassing. If I am not mistaken, you are actuated by some feeling of annoyance. ... I have had no other...intention than to prepare you for employment of a higher order than you have hitherto been engaged on[3].

He reported later to Government that, ,

although Lieut. Rivers' talents, energy, zeal, and ability are undoubtedly of a high order, and an honour to the Corps of Engineers...still, from a want of a thorough grounding on his first entrance into the Department [IV, 74, 464], and from never having come in contact with other officers, ... he has always been a rough observer, and never kept his instrument in order.

My predecessor...recommended that Lieut. Rivers should be ordered to headquarters, which Government did not think fit to accede to. ... This defect in preliminary training has...been a cause of great anxiety; ... I accordingly availed myself of the opportunity afforded by Captain Renny-Tailyour's services lying in the vicinity of Lieut. Rivers to direct the latter to employ the remaining part of the season 1848–9, in assisting on the Great Longitudinal series. ...

He was afforded an opportunity of learning the use of the great theodolite and...the necessity...of scrupulous care in great geodetical operations. Captain Renny-Tailyour...carried my views into effect with consummate tact and delicacy. It was my intention that the Bombay party should have cantoned at Neemuch with the Great Longitudinal series, from which ...great improvement was expected, for no solitary Surveyor can ever attain excellence. ...

[1] DDn. 493 (XX), Rivers to SG., 8–5–49. [2] 20 paras, reducing to 6 closely typed pages of foolscap.
[3] DDn. 493, 19–5–49.

My plan was defeated by the great distaste which Lieut. Rivers exhibited, ... and I was reluctantly obliged to acquiesce in his wishes. ... I am happy to say, however, that...the style of Lieut. Rivers' operations during the ensuing season...vastly improved. ... I doubt whether he will ever attain that degree of refinement in observing and adjusting instruments which is essential in 1st-class geodetic operations. ... Observers fit for work of this kind are very difficult to be met with, more especially as, in India, ... a man must also be a good mechanic, and able to keep his instruments in order. Of this class the Department only contains...Captain Renny-Tailyour, Mr. Geo. Logan, and Captain Strange[1] [163].

DU VERNET

Waugh had been entirely satisfied with Du Vernet's work on the principal triangles of the Karara and Gurwāni series [12, 381]. After three seasons on the North-West Himālaya series, however, he found the observations gradually deteriorating in refinement, and was glad of the opportunity in 1850 of passing the principal triangles to the experienced hands of George Logan, and giving Du Vernet control of the topographical survey of the mountains to the north [36, 200].

As this work was drawing to a close he decided in 1852 to move Du Vernet to the Assam Longitudinal series which he regarded as too important to be entrusted to one of the assistants. The start of this series passed through the water-logged, fever-ridden, plains of north Bengal, and Du Vernet did not appreciate the transfer, more especially as he was now over 50 years of age, and had a wife and family at Mussoorie[2]. He protested verbally before he left Mussoorie, but Waugh was firm and insisted on the move, making a point of visiting the party in the field at the end of January 1853 after Du Vernet had taken over charge.

Du Vernet made written protest just before the visit ;

After having made arrangements and issued orders for my different parties in the field [for Himālaya area], and without any previous intimation, I was desired at only two days notice to deliver over charge of the North-West Himalaya series, and proceed about a thousand miles to Assam. ... I should have been allowed to complete the work on which I was engaged, ... having laid down the system for the survey, instructed the surveyors, and led the party in the field. My character as a topographical surveyor is much concerned [200–7]. ...

The secrecy observed, ... together with the manner of effecting my removal, appears inexplicable, and as opposed to the interest of the public service as to my individual convenience, the consideration due to my service in this Department, and the rank held by me in the army[3].

There had been personal meetings both at Mussoorie and in the field, and in a letter written before they parted in January Waugh criticised the management of the Himālayan survey, and explained his reasons for moving Du Vernet to Assam after he had declined transfer to charge of the Hyderābād survey [384, 395]. Du Vernet retorted with a long and virulent letter ;

The suddenness and unexpectedness of the removal of which, though living with you on the most friendly terms, you had not given me the slightest hint, was cruel and unjust, and the climate of Assam is the worst in India. ... I had...to obey, and to appeal. ... I was most anxious for my character as a surveyor, and alarmed for my very appointment in the Department. ... I had been removed without any reference to Government, and without being consulted, ... or any reason given. ... Travelling by public conveyance instead of performing regular marches, I could and did arrive on the new ground...one month before your camp. ...

The Surveyor General did not seem to appreciate his work in the mountains ;

The country lying between the Jumna and Ganges, the Siwalik Range, and the great snowy ridge towards Tibet, ... of which there are no correct maps, is considered by you not of sufficient importance to retain...the services of an officer of my rank and standing. ... When it was once determined...to have a commissioned officer in charge of the Assam series I ought to have been warned. ... I was the only commissioned officer available, ... Captain Tailyour being about to retire. ... The Assam series is merely a continuation of the series running from Attock to Darjeeling that has been conducted by commissioned officers and by civilians. ...

[1] DDn. 542 (37), 20–8–50. [2] a 2-yr. old son d. Aug. 1852, and dau. b. April 1853. [3] DDn. 606 (148), to SG., 11–1–53.

The sub-assistant surveyor [Nicolson] whom I have superseded has given you great satisfaction in conducting the Parasnath series [15–6]. ...

In my correspondence I have endeavoured to observe the greatest moderation and to avoid writing anything offensive, ... but I regret you have not observed the like moderation in your letter, the style of which is not consistent with the courtesy to be observed towards an officer. ... With regard to this correspondence, it will depend upon yourself to say whether it should be laid before Government, but I am desirous it should be, to prevent further discussion[1].

Du Vernet was indeed far from "a polite letter-writer", and Waugh returned this letter with caustic remarks in the margin, and called for its withdrawal ;

(a). Major Du Vernet was chosen for this duty, not because the Assam climate was considered unhealthy, but because the arrangement was the best I could make. ...

(b). Two days...was amply sufficient to make over charge. ... Major Du Vernet was not sent away on 2 days notice. ... He did not quit quarters until full six weeks afterwards. ...

(c). No officer can be allowed to dictate how and where he should be employed [IV, 389]. ... I considered him better fitted for the topographical than the geodetic work. I would never have employed him on the N.W. Himālya series except for his topographical qualifications. In other respects he is not equal to my other geodetical assistants. ...

(d). Major Du Vernet went [into the Himālaya] with the greatest reluctance, prognostigaing failure, and thus greatly diminished the credit due to him. All the arrangements were made by me and the most competent assistants were supplied. Major Du Vernet only accompanied the party, and the observations were taken by the assistants. ...

(e). This is a very improper style of address to a superior, ... and quite incorreot. It is not merely by issuing orders that work is properly done, but by careful training. ...

(f). This is idle rambling. ... This is quite unintelligible...[and regarding the concluding paragraph]—These assertions exhibit great effrontery—This is an uncivil mode of expression to say the least[2].

Whilst Du Vernet withdrew the offending letter he repeated that he still felt "aggrieved in many matters". Waugh was not satisfied ;

The withdrawal of your letter should be bonefide cancelment of all it asserted, and...your expression of regret should be a candid apology. You have evinced towards me great disrespect and hostility by the offensive style of your correspondence—by disputing my authority—by setting up your opinion against mine in dictatorial terms—by meddling with questions that do not concern you—by accusing me of cruelty and injustice—and by asserting that one of my acts is injurious to the interests of the State. ...

If I do not receive a plain statement [of withdrawal]...by return of post, allowing...a reasonable time for reflection and for accidental delays in transit, I shall...report your conduct for the...orders of the Governor General in Council[3].

Du Vernet remained defiant and asked that all the correspondence should be laid before Government which was accordingly done, Waugh commenting that

Major Du Vernet perpetually wrangled with my predecessor, and that the cessation of this habit since he came under my orders is attributable to my conciliatory line of conduct and the forbearance I have manifested on occasions when my patience has been severely tried. ... It is not always practicable to study personal convenience[4].

Government fully supported him and asked him to convey to Du Vernet their severe displeasure and warn him that any repetition of such conduct would entail his removal from the Survey[5].

Being dissatisfied by Du Vernet's small output Waugh called for copies of his observed angles, and sent them to be examined by Renny, Strange, and Logan who confirmed his impression that they were not up to standard, though his theodolite was one of the best"[6]. Renny found Du Vernet's Assam observations "not as accordant as may be reasonably expected...and...quite unfit to be admitted into the Trigonometrical Survey of India"[7]. Strange was even more emphatic, and in communicating these verdicts to Du Vernet Waugh commented that his observations on the North-West Himālaya series had been "gradually deteriorating...[presumably from increasing infirmities of vision and physical power"[8] [30].

[1] DDn. 606 (153), Du Vernet to SG., 10–2–53. [2] ib., notes by SG., 10–3–53. [3] DDn. 602 (151), from Du Vernet 17–3–53 ; ib., 591 (294, 297), from SG., 10–3 & 7–4–53. [4] DDn. 547 (25), to Mil. Dept., 17–5–53. [5] DDn. 546 (225), from Mil. Dept., 10–6–53. [6] Waugh's 24″ No. 2, tested by Logan 1847, used by Renny, 1850–1 & Du Vernet, 1852–3 [153]. [7] DDn. 569 (167–8), Renny. Tallyour to SG. 9–8–53. [8] DDn. 591 (332), 22–9–53.

Another bitter exchange of letters passed between the two till Waugh ordered that "all further correspondence on the subject may cease", and at Du Vernet's request passed the papers to Government with a recommendation for his removal ;

Notwithstanding his intractibility and the unsatisfactory character of his recent work, I do conscientiously believe that Major Du Vernet has all along zealously and honourably done his very best. ... I proposed to recommend him...for the charge of the Hyderabad topographical survey [384, 393]. ... The bare suggestion...excited his animosity, and being thoroughly convinced...not only of his fitness, but of his superiority to all others, he declined to leave the Trigonometrical Survey. ... This delusion, so apparent to other members of my Department, has been fostered by his unsociable segregation from...his brother officers. ...

Major Du Vernet was originally a coarse observer. With great pains I worked him up to a moderate sense of refinement, after attaining which...he has gradually deteriorated from bad to worse. ... I saved Government from loss by removing him...to geographical work. ... He is now so unfit—so inclined to be troublesome—and so wrong-headed—that it is not desirable that he should be employed in any branch of the Survey Department any longer[1].

Government agreed "that Major Du Vernet is not fit for the Department and... ought to be relieved", but "having regard to his long standing...in the service" he would be permitted to tender his resignation[2]. This was accepted and in March 1854 he left for Rangoon to take up a post in the telegraph department [141].

SAXTON

Saxton was more than once the target of rebuke by the Surveyor General, whether on account of unsatisfactory professional work—or for breaking off his field work with undue haste [367–8]—or pushing his personal affairs, salary, or departmental status. It was on this last account that Waugh returned a letter that Saxton had written but one week after his wife's death ;

The last paragraph exhibits want of subordination and respect for the Surveyor General's legitimate authority. ... It is the undoubted duty of the head of the Department...to dispense praise and blame where each are due—to express satisfaction and dissatisfaction according as they may be merited—and to state his opinions fearlessly without favour or partiality.

If, therefore, the Surveyor General is not to express his sentiments when he happens to differ...from his officers, what would be the value of his opinion when he approves ? ... If his subordinates are to rebuke the Surveyor General for differing with them, and to warn him that their zeal will evaporate when they are found the slightest fault with, there is an end of all discipline. ... Unless the last paragraph...is withdrawn and apologised for, and the rest submitted in modified form, the case must go on up to higher authority for orders[3].

Saxton promptly withdrew the offending letter and apologised, and Waugh wrote later to Thuillier that he would gladly have

recommended the transfer of Saxton's party to Bengal and Bengal rates, but he made a mess of it [399]. He wrote in a most dictatorial impertinent manner, reaching me when I was very ill. I can stand of good deal of bullying and impertinence in silence, but I cannot do what I am urged to do in a very unpleasant way. ... It is more dignified to look down on, and pass unnoticed, everything uncivil and disagreeable. ... I wish I had your temper and disposition. I would give you no end of money if you would transfer it to me. Yet I hardly think even you—*teres atque rotundus*—would stand all I have endured...in patience[4].

REVENUE SURVEYS : BENGAL

When Wroughton assumed charge of the Revenue Surveys of Bengal he found only four surveys in progress, three in Bihār and one in Midnapore, Walter Sherwill being the only military officer. The Department was reinforced by the return of Ralph Smyth in 1847, in which year also Henry Thuillier returned and took over duty as Deputy Surveyor General and Superintendent of Revenue Surveys in relief of Wroughton who had long been in bad health.

[1] DDn. 547 (187, 195), 8 & 11–10–53. [2] DDn. 551, from Mil. Dept., 11–11–53. [3] DDn. 592 (244), 29–8–55. [4] sg. fd. corr. ; SG. to DSG., 26–9–56.

In 1846, after the 1st Sikh War, revenue surveys were called for in many parts of the North-Western Provinces and the Punjab, and a number of military officers were brought in. Henry Stephen had been trained under Henry Lawrence to regard speed as more important than precision, and his work in the cis-Sutlej area between 1846 and 1851 had to be largely revised [IV, 226–7]. His party was then taken over by Robert Shortrede who had many years service on the Great Trigonometrical Survey and some experience of revenue survey in Bombay [IV, 236].

Thuillier was further critical of Thomas Blagrave who held charge of the trans-Sutlej survey for several seasons ; he was

painstaking and conscientious...[but] wanting in method and system. ... His work shows evidence of his not being a good man of business. ... The real fault consisted in demanding and encouraging an excessive amount of work. This...detained...[him] at Lahore for several months until the whole of the records could be put into proper order[1] [273].

An extremely capable surveyor was found in Donald Vanrenen who had worked in Sind, and was then posted under Stephen, and from 1847 held charge successively in Ajmer, Rohilkhand, and the Central Provinces. He rose to become D.S.G. and Superintendent. Other successful surveyors were Gastrell, Hunter Thompson, Anderson, and John Macdonald, who all joined in the Punjab and held responsible charges for many years. Henry Johnstone who joined in 1853 won a great reputation on the North-West Frontier.

Of others who were still junior officers by 1861 were Adrian Vanrenen cousin to Donald, Oakes, Donald Macdonald, and Sconce, the last-named becoming D.S.G. in 1879. Many lost their lives from the climate or other causes. Burgess and Turnbull were killed by mutineers in 1857. Willoughby was wounded at the siege of Balaghāt near Saugor and compelled to take furlough to England where he died two years later. Hutchinson and St. George both died in the hills during recess, whilst James Sherwill, younger brother to Walter, died at sea on the voyage to England on sick leave. Some left the survey early to follow successful careers in the Army or the Punjab Commission.

The importance of maintaining a number of young officers under training had been fully established during the survey of the North-Western districts [IV, 362–3], and the Board of Revenue at Calcutta pointed out that, "as military officers are... liable to be withdrawn from civil employ, ... it might...be advisable to attach a second military officer...to each officer in charge, who would thus...become qualified to assume the control whenever occasion arose"[2].

The failure to maintain such provision resulted in disaster when Sherwill took furlough in 1848 [241, 254–5]. Thuillier made this a strong point when he pressed three years later for the appointment of "two young officers as assistants", but such appointments were never made as a matter of course and Thuillier pointed out again in 1859 that "unless this is done the efficiency of the Department cannot be maintained"[3] [365]. The establishments of the Punjab parties, however, made due provision for assistants, and Thuillier protested that,

at the time of Capt. Dennys' appointment [266], there were at least half-a-dozen Assistant Surveyors available in the Department fit for charge. ... The appointment of an outside officer has a most injurious tendency on the working of a large department, ... and is likely to deter officers of real merit and high qualifications from entering it[4].

Officer appointments rested with local governments who did occasionally consult the Superintendent. Thuillier writes shortly after he had taken office ;

The Lieutenant Governor...wrote to me regarding the Ajmere survey, and I mentioned the name of Lieut. Vanrenen, who has been employed in Sind, and latterly under Captain Stephen. ... Though personally quite unknown to me, I thought he was the only man of experience now out of employ, and I hear he is a very energetic fellow indeed. I have this day had a reply from Mr. Thomason saying that he had appointed Vanrenen, and...felt quite sure he would do justice to the work. ...

[1] DDn. 624 (71), DSG. to SG., 5–4–56. [2] BRC. 6–5–44 ; from Rev. Bd., 18–4–44 ; cf. DDn. 562 (144), Rev. Dept. to Rev. Bd., 16–8–51. [3] *Rev. Bd. LP. 1849–50*, 10–10–50 ; & *1857–8*, from DSG., 2–15–59. [4] DDn. 624 (47), DSG. to SG., 5–4–56.

Captain Smyth has taken charge of this 24-Purgunnah survey. It is one of considerable difficulty and importance. ... The late incumbent [Wilson]...let everything go wrong [247, 304]. Smyth is a man of the most indefatigable powers. He gained much credit in Cuttack [IV, 187], and I am sure will give great satisfaction. His...talent as a draftsman is first rate[1].

Though the duties of revenue survey did not demand knowledge of mathematics and such scientific talents as did the geodetic work of the G.T.S., yet they called for high ability in the control of traverse, mapping, and general organization, and most of all in management of men. In urging the importance of Murree as recess station Johnstone noted that the Lieutenant-Governor[2] made it his summer quarters and "likes a good superior class of men like Survey Officers about him"[3].

Thuillier protested strongly against the regulation which forbade officers spending more than five years in staff employ ;

The various qualifications which I have...recorded...have only been derived by incessant labour, study, and practical experience, in every description of country...in this wide presidency, on the part of...as fine and reliable a body of officers as ever served the Government. ... The execution of surveys over difficult ground and through inhospitable tracts...in a climate like India cannot be performed at the same expense, or with the same accuracy, by raw hands. ...

To deprive the Department, therefore, of the services of a single member whose ability, energy, and experience is proved would lead to the most embarassing consequences.

Major W. S. Sherwill...since 1853 has been deputed to convert the chaos of fiscal confusion in the territorial boundaries of Behar and Bengal into some definite order [256–7]. ... He has been appointed, in addition, Professor of Surveying to the Civil Engineering College at the Presidency. ... He is, therefore, now fully and laboriously employed. ... I consider Major Sherwill...an ornament to this Department.

Captain D. C. Vanrenen, ... prior to joining this Department, had some experience in surveying and levelling for canals in Sindh [192–3].

Captain George Hunter Thompson is an officer of great merit, ... and energetic in the highest degree. ... He has been in a good school in the Punjab, and always turns his means to the best account. Working hard himself and shewing a good example, he exacts much from his subordinates, ... somewhat severe in temper ... but...a very valuable member of the Department.

Captain James E. Gastrell is a first-rate surveyor...having been brought up as a Civil Engineer, and taking a high place at Addiscombe at a period when the Engineers and Artillery were overstocked. ... His...delicate management of a large staff of assistants has been most successful. No officer deserves more credit for good and reliable work.

Lieut. F. C. Anderson is a...surveyor with whom it is a great pleasure to act. After a long apprenticeship as Assistant Surveyor in the Baree Doab, he succeeded to...charge in Novr. 1857, since when he has...completed the last doab in the Punjab proper in a masterly manner.

Lieut. J. Macdonald, appointed to charge of the Sindh Survey on the 24th December 1855, is a very active and hard-working surveyor. ... As an Assistant in the Punjab...was inclined to too great haste. ... Is now more alive to the necessity of care in his work. ... In temper and judgement this officer has also greatly improved since he has held independent charge.

Captain H. C. Johnstone is another excellent officer brought up in the Punjab school, and his conduct of...operations west of Indus, is deserving of the highest commendation. ... Deputed to take up the topographical survey of the Derajat, which he has now carried out...in an admirable and fearless manner, evincing very high qualities both military and administrative, for which he has obtained the marked approbation of the Punjab Government. The style of this surveyor's work is everything I could wish ; his maps are executed with great clearness and beauty, and the detail...full and complete [219].

Lieut. Edward Willoughby...served as Assistant Surveyor in the Saugor District. ... He is a capital draftsman and...is particularly neat and careful in all he undertakes. ... He succeeded to the independent charge of a party whilst in the Fort of Saugor in 1857, just after receiving a very severe wound when volunteering...against the fort of Balaghat the gate of which he blew up. Debris of the masonry falling on him caused a compound fracture of the leg from which he has not yet recovered having been obliged to take furlough to Europe in April 1858.

Lieut. Adrian Vanrenen, specially educated as a Surveyor, in which capacity he was licensed at the Cape, and with some experience in the Department of Public Works brought peculiar qualifications with him to the Department. ... One of the most energetic and useful officers in the Department, and his conciliatory disposition endears him to all his subordinates.

[1] DDn. 472 (113–8), DSG. to SG., 3–7–47. [2] Sir John Lawrence, Lt. Govr. 1859–64. [3] DDn. 30 (111), 18–8–62.

Lieut. John Hayes Grant is an intelligent officer with plenty of ability, but wanting in method, system, and fixity of purpose. ... Entrusted with the officiating charge of a party in Nagpur and since that period has shewn decided improvement.

Captain James Lind Sherwill...is like his brother an accomplished draftsman and in energy and determination second to none. ... Whilst employed in the Derajat...under Captain Johnstone he...appeared peculiarly well qualified for frontier work. ... He took charge of the Dinajepoor party...and the happiest results have shewn themselves from the firm and good management he has exercised over a party partially disorganized.

Capt. W. S. Row as an assistant Surveyor...was confined to office duties owing to the infirm state of his health. ... Placed in officiating charge, ... but...his management was not successful, and he left the work and the establishment in a disorganized state. ... Deficient in administrative capacity, and unequal to the active duties of such a laborious profession[1].

BOMBAY

Bombay revenue surveys were divided into three divisions, each under a civil or military Superintendent of Revenue Survey and Settlement. The surveyors, mostly officers of infantry, were granted magisterial powers as Assistant Collectors to enable them to settle boundary and other disputes. Each Superintendent had several military assistants and civil assistants or sub-assistants. In most areas the assistants were charged with both survey and assessment of revenue.

In 1844, Wingate was Superintendent of Survey and Settlement in the South Marātha Country with headquarters at Dhārwār. Promoted Revenue Commissioner in 1851, he was succeeded by William Anderson.

At Poona, Nash held charge of the Deccan division till 1846, and was followed first by Goldsmid, and in 1850 by James Francis who carried the survey into Thana. When Francis took furlough pending retirement in 1876 he held office as Survey and Settlement Commissioner, Poona and Nāsik.

At Ahmadnagar David Davidson [IV, 429] held charge of the Nāsik division till he handed over to George Anderson in 1848.

Other surveyors who succeeded as Superintendents in due course were Prescott, Laughton, Taverner, and Malcolm Haig.

SURVEY ALLOWANCES

Though officers of the Great Trigonometrical Survey drew full salary right through the year [IV, 352 ; V, 381], Revenue Surveyors were liable to reduction to Rs. 250 p.m. during the three months of recess but, as it was impossible to define this period for all surveyors it was decided at the 1833 conference that Revenue Surveyors should draw a flat rate of Rs. 526 p.m. throughout the year [365]. In addition they were allowed a contract allowance of either Rs. 100 or Rs. 200[2] throughout the year from which they were to meet all contingent charges [IV, 364, 392]. Assistants, 2nd class, G.T.S., and Assistant Revenue Surveyors drew Rs. 250 p.m. All these salaries were additional to military allowance of rank.

Officiating and absentee allowances provided that the absent surveyor should draw half salary, whilst his relief drew the forfeited half [IV, 365] in addition to half his permanent salary, or Rs. 388 in all. When Thuillier was acting as D.S.G. in 1847, he drew less staff pay than his juniors in charge of field parties.

Officers of the Madras and Bombay establishments were on altogether different scales except when appointed to the G.T. Survey. Saxton drew only Rs. 350 p.m., for charge of the Orissa topographical party, this sum being made up of Rs. 180 staff salary and Rs. 170 charge allowance [III, 350–1]. On his pointing out the difficulty of maintaining himself in such difficult country, and on the strong recommendation of the Surveyor General he was allowed an extra Rs. 100 p.m.[3]

[1] DDn. 668 (249), DSG. to SG., 28–12–59. [2] whether single or double establishment. [3] DDn. 588 (145), CD. to B., 22–3–54.

as personal allowance [385]. When he took furlough he was allowed one half the staff salary and personal allowance, making Rs. 140, whilst the whole of the charge allowance was drawn by Depree who officiated for him[1]. In 1859, on the Surveyor General's strong recommendation both Saxton and Depree were brought on to the Bengal establishment and allowed staff salary @ Rs. 618 p.m., Saxton's personal allowance being discontinued[2].

Allowances for the military topographical assistants on the Kashmir survey were fixed at staff salary of Rs. 100 a month with Rs. 60 p.m. travelling allowance. When posted permanently to the G.T.S., in February 1858 staff salary was raised to Rs. 250 p.m., being that of a 2nd Assistant G.T.S.[3].

It may be noted that in 1863 Fitzroy in charge of the Pegu survey paid income tax Rs. 16–8 on survey salary of Rs. 550 p.m.

Though officers of certain parties drew a special "hill marching allowance" [375] no regular travelling allowances were authorized as for other departments, military and survey allowances having been originally calculated to cover all camping and travelling expenses [376]. " The Survey alone " writes the Surveyor General "remains nearly in its primeval state as regards salaries"[4] [383, 408]. It was not until Thuillier had followed up Waugh's vigorous letters of 1860, and after an exhaustive examination by Colonel Dickens, that the whole scale of pay of the Department was revised on more generous terms[5] [376].

Survey allowances for the Bombay Revenue Surveyors were laid down in 1842 [IV, 367]. As Superintendent at Ahmadnagar in 1850, Anderson drew a further consolidated travelling allowance of Rs. 300 a month[6].

NOMINAL ROLLS

Name	Corps	Appd. to Svy.	Employment	Remarks
GREAT TRIGONOMETRICAL SURVEY				
BASEVI	Ben. Engrs.	17–1–56	Gt. Indus, 1856–60; Kashmir, 1857; East Coast, 1860–3.	d., Changchenmo, 1–7–71.
BRANFILL	Ben. Cav.	4–10–58	Levelling, 1858–62.	ret., 10–11–84.
BROWNLOW	Ben. Engrs.	4–2–56	Kashmir, 1856–7.	kd. Lucknow, 18–3–58.
DU VERNET	Mad. Eur.	18–3–40	N. Conng. 1841–4; Karara, 1844–5; Gurwāni, 1845–7; NW. Himālaya, 1847–52; Assam, 1853–4.	to Tel. Dept., Burma, March 1854.
GARFORTH	Ben. Engrs.	13–10–43	Chendwar, 10–3–44; in ch. Gora, 1844–7	resd., 1–9–47.
HAIG	Bo. Engrs.	29–8–59	Bo. trgn., 1859–84 S.T.S. 1884–9.	ret. age 55, 12–10–89.
HERSCHELL	Ben. Engrs.	3–11–59	Gt. Indus, 1859–60; Sutlej, 1860–1.	ret., 10–3–86.
HILL [IV, 447]	Mad. Inf.	31–1–45	from Mad. topo.; East Coast, 1845–51.	leave on mc. 1851–3, left India, Dec. 1853.
MONTGOMERIE	Ben. Engrs.	20–8–52	Bahun, 1852–3; Chach & Karāchi, 1853–5; Kashmir, 1855–65.	resd., March 1876.
NASMYTH	Bo. Engrs.	14–11–51	Bo. trgn., 1851–70.	after many spells sick leave, resd., 20–9–71.
OLIVER	Ben. Engrs.	29–7–59	... ...	d. Mussoorie, 14–10–59.
RENNY-TAILYOUR [IV, 462–3]	Ben. Engrs.	23–7–32	Maluncha, 1844–5; furl. 1845–7; Gt. Longl., 1847–9; Astr. Asst., 1849–54.	resd., 1–1–54.
RIVERS [IV, 464]	Bo. Engrs.	10–6–42	Bo. trgn., 1842–53.	furl., March 1853.
SHORTREDE [IV, 465–7]	Bo. Inf.	23–9–39	Bo. trgn., 1839–40; Karara, 1841–45.	to mil. duty, 6–3–45.
STRANGE	Mad. Cav.	24–2–47	Gt. Longl., 1848–53; Chach & Karāchi bases 1853–5; East Coast, 1855–60.	mil. duty, 9–8–60.
TENNANT	Ben. Engrs.	24–10–51	Gt. Longl., 1851–53; Gt. Indus, 1853–6; Jogi-Tila, 1856–8; Gurhagarh, 1858–9.	offg. Astr. Madras, 1859–60; PWD., 1860–7.
THUILLIER, H. R.	Ben. Engrs.	21–5–59	Gt. Inus, 1859–60; Kashmir, 1861.	SG., 1887–95.
WALKER, J. T.	Bo. Engrs.	1–12–53	Peshāwar 1849–53; Jogi-Tila, 1853–6; Gt. Indus 1856–61; STS., 1861.	SG. & STS, 1878–84.
WALKER, R. J.	Ben. Engrs.	13–9–44	Chendwar, 1844–5; ch. Maluncha, 1845–7.	d., nr. Darjeeling, 23–4–47.
WAUGH [IV, 472–4]	Ben. Engrs.	2–7–32	SG. & STS., 16–12–43 to 12–3–61.	ret. 12–3–61.
TOPOGRAPHICAL SURVEYS				
ALLGOOD	Ben. Inf.	28–2–56	Kashmir, 1856.	mil. duty, Sept. 1856.
AUSTEN	HM. 24th Ft.	5–4–57	Kashmir, 1857–9; 1860–3.	leave pending ret., 11–8–25.
HAGGIE	Ben. Engrs.	5–12–62	Pegu, 1862–4.	mil. duty, 1864.
BLAIR	Mad. Art.	1–8–56	Pegu, 1856–7; 1858–9.	mil. duty, 1859.

[1] DDn. 548 (109), Civ. Audr. to Mil. Dept., 21–6–56. [2] DDn. 643 (259), SG. to Mil. Dept., 11–11–58; DDn. 728 (37), Mil. Dept., 25–2–59. [3] DDn. 641 (433), Mil. Dept. to SG., 6–10–57 & 715 (351), 22–2–58. [4] DDn. 2 (151), SG. to Mil. Dept., 22–5–& 17–10–60. [5] Fin Depot. 22–4–65 & 22–9–66. [6] cf. Bo. Rev. Dept., 163/1847 (11–2), 24–12–41.

Name	Corps	Appd. to Svy.	Employment	Remarks
BODDAM	Bo. Engrs.	April 1850	Gujarāt, 1850–3.	mil. duty, 1853.
BROWN	Mad. Cav.	14–3–48	Hdbd. Svy., 1848–50.	mil. duty, Dec. 1850.
DEPREE	Ben. Art.	20–10–54	Orissa, 1854–60 ; Chota Nāgpur, 1860–8.	SG. 1884 to death, 18–2–87.
EDGECOME	Mad. Engrs.	Dec. 1854	Pegu, 1854–9 ; 1865–7.	mil. duty, 1867.
FITZROY	Ben. Art.	26–9–56	Pegu, 1856–65.	mil. duty, 1865.
HALPIN	Mad. Inf.	18–10–42	Ganjam, 1844–8.	d. Ganjam, 30–11–48.
JOHNSON, Chas.	Ben. Inf.	28–2–56	Kashmir, 1856.	mil. duty, Sept. 1856.
LUMSDEN	Ben. Inf.	28–2–56	Kashmir, 1856.	mil. duty, Sept. 1856.
MC MAHON	Mad. Inf.	Oct. 1856	Pegu topo. so. rev. Nov. 1856.	Burma Commn. 25–1–56 to 20–4–78.
MELVILLE	Ben. Inf.	8–4–57	Kashmir, 1857–63.	d., Mymensingh, 15–2–71.
MORLAND	Mad. Inf.	12–2–28	Hdbd. svy. 1828–48.	mil. duty, Jan. 1848.
MURRAY	Ben. Inf.	12–4–57	Kashmir, 1857–8 ; Punjab, 1858–60 ; CI., 1860–3.	ret. after 1882.
OUCHTERLONY	Mad. Engrs.	28–3–44	Nilgiri Hills, 1844–52.	mil. duty, Dec. 1852.
ROBINSON	Ben. Engrs.	19–7–50	Mil. Svys., 1847–50 ; Pindi & Jhelum. 1850–60 ; CI., 1860–3 ; offg. STS., 1863–5.	Dir. Telegraphs, 1865.
SAXTON	Mad. Inf.	24–4–40	attd. GTS. 1849–50 ; Orissa topo. 1850–60 ; Khōnd Hills, from 1861.	leave pending ret., 1873.
STEWART, R. C.	HM. 84th Ft.	12–9–54	Pegu, 1854–6.	mil. duty, 1856.
TREVOR	Ben. Engrs.	22–1–54	Pegu, 1854–6.	mil. duty, 1856.
WILLIAMS	Ben. Engrs.	4–1–53	Pegu, 1853–56.	Prepl. Civ. Engr. Coll. Ft. Wm., Sept. 1856.

REVENUE SURVEY : BENGAL

ANDERSON, F. C.	Inf.	10–9–52	Punjab, 1852–9 ; to Oudh, 1859.	c., 1–11–83, aged 56.
BATTYE, G. M.	Eur.	13–11–50	Punjab, 1850–2.	Punjab Comn., Nov. 1852.
BATTYE, H. D.	Inf.	10–9–52	Punjab, 1852–5.	Punjab Comn., Jan. 1856.
BECHER, J. R.	Engrs.	15–11–46	Punjab, 1846–7.	Punjab Comn., Oct. 1847.
BLAGRAVE, J. W. B.	Inf.	15–11–47	Punjab, 1847–52 ; Saugor, 1854–7.	d. Saugor, 6–10–57.
BLAGRAVE, T. C.	Inf.	10–2–47	Punjab, 1847–56.	furl. 10–4–56.
BURGESS	Inf.	29–9–47	Ajmer, 1847–8 ; Delhi, 1848–9 ; Rhlkd. 1849–53 ; Bdlkd., 1853–7.	kd. Jhānsi, 8–6–57.
CAMPBELL, E. F.	HM. 60th	16–9–53	Punjab, 1853–7.	mil. duty, 1857.
DENNYS	Inf.	20–10–54	Rājputāna, 1854–5.	mil. duty, 1855.
ELLIOT, M.	Inf.	1858	Punjab, 1852 ; Chota Nāgpur, Dec. 1858.	resd., 1–5–59.
FITZGERALD	Inf.	13–11–50	Punjab, 1850–1.	dr. at sea, 8–5–52.
FULLER	Art.	8–11–53	Rohilkhand, 1853–5.	Education Dept., May 1855.
GASTRELL	Inf.	13–1–52	Punjab, 1852–3 ; Bengal, LP., from 1853.	ret., 1–4–76.
GRANT, J. H.	Art.	18–3–56	NWP. & CP., 1856–61.	d., 12–11–68.
GRIFFITHS C. J.	Inf.	9–3–59	Derajāt, 1859–62.	resd., 1862.
HAMILTON	Inf.	15–12–51	NWP., 1851–9.	Pol. Dept., 1859.
HUTCHINSON	Art.	30–7–46	Punjab, 1846–8.	d., Simla, 3–9–48.
JAMES, H. C.	Inf.	17–3–48	Bengal LP., 1848–9 ; Bihār, 1849–50.	furl., 10–4–50.
JOHNSTONE, H. C.	Eur.	27–5–53	Derajāt, 1853–09 ; Delhi, 1861–3.	leave pending ret., 6–5–77.
MACDONALD, D.	Inf.	19–10–60	Bengal LP., 1806.	mil. duty, aged 55, 10–12–90.
MACDONALD, J.	Inf.	4–9–52	Punjab, 1852–6 ; to Sind, March 1856.	leave pending ret., 6–5–77.
OAKES	Inf.	7–4–58	Bengal LP., 1858–60 ; to CP., 1860.	leave pending ret., July 1876.
ROW	Inf.	21–8–55	Ben. LP., 1855–9 ; Chota Nāgpur, 1860–6.	mil. duty, 1866.
ST. GEORGE	Art.	8–10–60	Oudh, 1860–1.	d. Landour, 14–10–61.
SCONCE	Art.	21–10–59	Bdlkd. & CP. ; DSG. 1879.	ret., 2–4–91, aged 55.
SHERWILL, J. L.	Inf.	26–9–56	Derajāt, 1856–9 ; Bengal LP., 1859–63.	d. at sea, 12–1–64.
SHERWILL, W. S.	Inf.	25–7–38	Bihār & Bengal LP., 1838–54 ; Bdy. Comnr., 1854–60.	ret., 31–12–61.
SHORTREDE	Bo. Eur.	20–2–51	GTS. 1839–45 [399] ; Punjab, 1851–6.	mil. duty, 17–10–56.
SMYTH	Inf.	20–11–37	furl., 1843–7 ; Bengal LP., 1847–57.	leave pending ret., 1–10–57.
STEPHEN	Inf.	25–11–37	NWP. & Bihār, 1837–44 ; furl., 1844–6 ; Punjab, 10–10–46 to 1851.	furl., Feb. 1851.
STEWART, W. J.	Art.	20–10–60	Ben. LP. 1860–73.	ret. after 1873.
TAYLOR	Art.	4–1–61	No. 2 Div. Nāgpur	d. at sea, 20–7–74.
THOMPSON, G. H.	Inf.	28–8–50	Punjab, 1850–8 ; Chota Nāgpur, 1858–66.	mil. duty, 3–11–66.
THOMPSON, P.	Art.	6–10–58	Punjab, 1858–9 ; Oudh, 1859–63.	resd. 31–12–63.
TICKELL	Inf.	9–2–48	Bhāgalpur, 1848–9.	pol. duty, 1849.
TURNBULL	Art.	11–10–55	Bundelkhand, 1855–7.	kd. Jhānsi, 8–6–57.
THUILLIER, H. L.	Art.	3–1–37	Ben. LP., 1837–44 ; furl., 1844–7 ; DSG., 1847–61.	SG., 1861–77.
VANRENEN, A. D.	Inf.	8–7–56	Rājputāna & Bdlkd, CP. & NWP.	leave pending ret., 13–11–73.
VANRENEN, D. C.	Art.	3–10–46	Punjab, 1846–7 ; Ajmer, 1847–8 ; Rhlkd., 1848–54 ; CP., 1854–59 ; Oudh, 1860–66.	DSG. 1866 till ret., 31–12–78.
WILLOUGHBY	Art.	11–9–54	CP., 1854–8 ; wounded 1857.	furl., 1858 ; d. 1860.
WROUGHTON	Inf.	19–10–21	NWP., 1821–42 ; furl., 1842–4 ; DSG., 1844–7.	sick leave, 1847–9 ; inv., 1849.

REVENUE SURVEY : BOMBAY & BEHĀR

ANDERSON, G. S. A.	Inf.	3–9–41	Biog. Notes.	
ANDERSON, W. C.	Inf.	2–3–42	Biog. Notes.	
BIGGS, Thos.	Art.	16–12–43	SMC., 1842–51 ; mil. duty, 1851. Ordnance Dept. 1858 ; ret. as Col., 14–9–65.	b., 22–4–22 ; d., 16–2–1905, son of Rev. Thos. R. Biggs, of Whitbourne, Hereford.
BOWLES, Alfred Arthur Loraine	Eur.	3–3–52	to mil. duty before 1859.	d., Ahmedābād, 29–3–56.
BOYE, Henry [IV, 369]	Inf.	6–6–42	Deccan, 1842–6. mil. duty, 1847 ; DJAG., N. Div., ret. as Col. 11–9–60.	b. 7–8–08 ; d. Marseilles, 16–3–73 ; son of Wm. Boyé Bo. Inf.
BRITTEN, Thos. Ernest	Inf.	12–10–59	SMC. ; Supt. Pensions, 25–10–65.	
BURGESS, Boughey	Inf.	2–9–45	Ahmadnagar, 1845–51.	
BURTON	Inf.	15–11–44	Biog. Notes.	
CAMPBELL, Alex. Duncan	Inf.	1846	Sind, 1846–7 ; appd. in India.	b. Cossipore 1822 d. Hdbd. Sind.
CHAMPION, James Hyde	Inf.	5–3–46	Deccan, 1846–8 ; mil. duty, for faulty work, 30–12–47.	b. 1823 ; d. 1895.
COLEBROOKE	Inf.	22–7–48	Biog. Notes.	

Name	Corps	Appd. to Svy.	Employment	Remarks
COWPER	Engrs.	3-7-50	Blog. Notes.	
CUMMING	Inf.	2-11-52	Blog. Notes.	
DAVIDSON, David	Inf.	5-12-37	Blog. Notes [IV, 429].	
DAY [IV, 369]	Inf.	30-8-41	Blog. Notes.	
DODS, Peter	Inf.	2-11-52	Deccan, 1853-9 till asst. Inām Comnr. 1858; DPI. CP. 13-8-62.	
DUCAT, Chas. Malet	Inf.	15-12-56	MC. 1856-8; furl. on mc. 17-12-68.	
ELPHINSTONE	Inf.	1-7-52	Blog. Notes.	
EVANS, Wm. Edwyn [IV, 369]	Eur.	14-12-41	Deccan, 1841-8; furl., 10-2-48. ret. as Col. 24-6-62.	b. 13-3-18; d. after 1888.
FANNING, Fredk.	Inf.	16-8-43	SMC., 1843-53 ret. as Hon. Maj., 13-3-58.	
FRANCIS [IV, 369]	Inf.	12-8-42	Blog. Notes.	
GLASFURD, C. Lamont Robertson	Eur.	17-5-55	SMC., 1855-60; to Berār, 1860; not in 1870 list.	
GRIFFITHS, Aug. Spottiswoode	Eur.	2-1-52	Deccan, 1852-3.	
HAGGARD, Thos. Trenchard	Art.	21-10-48	Amdngr, 1849; Nāsik, 1849-51.	b. 11-7-27; d., London, 23-7-77
HAIG, M. R.	Inf.	2-11-52	Blog. Notes.	
HOBSON, Julian Campbell	Inf.	21-5-55	Thana, 1855 till furl, 1861; ret. as M Gen. 1881	b. Deesa, 21-7-27 d. 29-5-87.
KEMBALL, Vere Seymour	Art.	21-2-44	SMC., 1844-53; 1858 with regt.	b. 10-8-25; d. Bombay, 18-10-59; son of V. C. Kemball, Surg.
LAMBERT, Walter Rathbone	Inf.	1846	Sind, 1846. SO. Sind 1858; Collr. Karāchi ret. as M Gen. 18.	b. 1824.
LANDON, Samuel	Inf.	7-1-39	Deccan to 1848 [IV, 369]; ret. as Col. 17-9-58.	b. 1804; d. 1890. Son of Phillip L., proctor, of Cape Town.
LAUGHTON	Inf.	19-12-51	Blog. Notes.	
LESTER, John Fredk.	Inf.	1848	from Deccan, tr. to Sind, 15-9-48.—Edn. Dept. Hdbd., Sind, 1859-60.	
LLOYD, John Hayes	Inf.	8-1-60	Thana & Ratnagiri, 5-9-64; Supt. Estates, Rajkot, 17-7-67.	
MACKENZIE, Geo.	Eur.	30-12-59	Hdbd., Sind, 1859-60; Berār, 1860-71, Mysore, 24-12-71 furl., 22-4-72 to 24-10-73; mil. duty 1-11-86.	b. 3-7-41 (?)
NASH	Engrs.	8-11-36	Blog. Notes, [IV, 459].	
NAYLOR, Chas. Edw.	Inf.	3-3-52	Gujarāt, 1852-3; DSP. Hdbd, Sind. 1858.	d., 17-5-1913, aged 83.
PHILLIPS, Alfred	Inf.	13-6-55	Gujarat, 1855-7. furl., 13-10-57. ret. as Maj., 13-7-69.	b. Sydney, NSW. 30-3-32; d., 23-6-90.
PIRIE, Wm.	Inf.	1846	Sind, 1846; DSP. Karachi, 1858 ret. as Lt Col.	
PRESCOTT	Inf.	11-9-50	Blog. Notes.	
RIGBY, Christopher Palmer	Inf.	1844	SMO.; HM Consul, Zanzibar, 10-3-58; ret. as M Gen. 1867.	b. 1820; d., 14-8-85.
SCOTT, Edwin Luddington [IV, 369]	Inf.	1841	Deccan, 1841-9; Amdngr. 1849-52; Deccan, 1853; with Regt. 1858.	living in 1889.
SCOTT, Stanley	Inf.	12-8-57	Khandesh; to mil. duty 1858.	
SCOTT, W.	Engrs.	1845	Blog. Notes.	
SOADY, Joseph Rogers	Engrs.	1850	asst. Engr. on svy. Narra R., Sind; Conolly (107-142) Ex. Engr. Canals 1858.	b., 30-3-30; d., Bath. 11-4-62; son of Capt., J. Soady, RN.
STATHER, Wm. Carlisle [IV, 369]	Inf.	10-10-39	Deccan, 1839-47, removed for faulty work, 30-12-47.	b. WI., 4-1-08; d., 27-9-93.
TAVERNER	Inf.	30-10-53	Blog. Notes.	
WADDINGTON, Thos.	Inf.	12-11-49	Gujt. & Amdngr. 1849-53; SMC., 1860; Edcn. Dept., 1864; ret. as M Gen. 31-12-81.	b., 26-4-27; d., Mentone, 31-1-1921; bro. of Wm. (*inf.*).
WADDINGTON, Wm.	Inf.	4-11-53	Poona & Thana, 1853-5; Supt. from 13-9-54; Thana & Ratnagiri, 1865 till furl. 18-4-69.	b. 1823; son of M Gen. Chas. Waddington.
WALLACE, Rayner	Inf.	1-6-54	SMC., 1854-64; furl., 1860; Berār Svy. 1864 till Dep. Supt. S.M.C. 1870.	b. 1826; d. 1871.
WESTROPP, James Edw.	Eur.	11-11-52	Deccan, 1852-6 till mil. duty China; ret. as M Gen.	b. 25-7-26; d., Nice 4-9-74, son of Capt., A. F. Westropp, RN.
WHITING	Ben. Engrs.	11-8-43	Blog. Notes.	
WINGATE	Engrs.	23-1-37	Blog. Notes [IV, 475].	

REVENUE SURVEY: MADRAS

CREWE	Mad. Inf.	8-6-58	Blog. Notes.	
HESSEY	Mad. Inf.	3-11-54	Blog. Notes.	
PRATT, R. Torrens	HM. 84th Ft.	1858	Blog. Notes.	
PRIESTLEY	H.M. 74th Hldrs.	22-2-53	Blog. Notes.	
SEARLE, Geo. Archimedes	Mad. Inf.	13-12-59	b. 1827. Rev. Svy. 1859-62; furl. on mc. Canals, Bengal, 14-2-68; ret. as M Gen.	1864-5;
WYNCH, Henry St. Maur	Mad. Inf.	23-8-60	Rev. Svy., 1860-2; b. 23-12-1833, son of Lt. Col. John Wynch, Mad. Art.; Capt. Henry Seymaur, changing name as here given, V. Timas, 18-8-89; ret. as Col. 1890.	

CHAPTER XXV

CIVIL ASSISTANTS : G.T.S.

Appointments & Postings — Allowances — Work — Misconduct — Successful Careers — Nominal Roll.

WHEN Waugh took over charge there were twenty civilian assistants and sub-assistants of the uncovenanted staff who, as it were, formed the backbone of, the Great Trigonometrical Survey. Of these Logan and James held charge of field parties, Peyton was Deputy Computer, and with six others, Armstrong, Radhanath Sickdhar, Clarkson, Lane, Keelan and Terry, had served with Everest from 1832 [IV, 371]. Five of these were still serving when Waugh retired in 1861.

The authorised establishment provided for twenty-three sub-assistants ; one Bombay and six Bengal parties with three sub-assistants each, and two extra for casualties. They were classified in 3rd, 2nd, and 1st classes, the normal interval for promotion being three years.

Besides these sub-assistants there were four selected posts—Chief Civil Assistant and 3 Principal Sub-Assistants [IV, 21, 374], these last in 1845 being held by Peyton, Armstrong and Lane[1]. On the resignation of Joseph Olliver in 1842 the post of Chief Civil Assistant had been left in abeyance until revived in 1848 by Peyton's promotion "as a just...reward for the successful completion of the Calcutta meridional series, as well as the zeal, ability, and high character uniformly displayed...during...long and arduous service"[2].

There was continual wastage but Government hesitated to fill vacancies "owing to the difficulty...in providing for the subordinates...on completion of the surveys [IV, 376, 393]". The Directors were, however, more far-sighted, and in 1846 Waugh issued instructions for training the recruits they had authorised ;

> While the Great Arc was in progress a majority of the sub-assistants were employed under the personal superintendence of the Surveyor General in the field, ... but this advantage has ceased. ... I have drawn up forms for reporting the qualifications of all candidates for promotion. These...are by no means to be...secret reports, and I am persuaded that the knowledge of his own character which a young man is likely to derive from the perusal of a document of this sort will tend greatly to his improvement. ...
>
> Encouragement should be given to sub-assistants of a studious turn who are desirous of pursuing the study of mathematics, ... which ought to be fostered as an indispensable qualification for the grade of Principal Sub-Assistant. ...
>
> The sub-assistants trained under my predecessor in the field became conspicuous for their activity, energy, patient endurance of hardships and privations, dauntless perseverance under difficulties, cheerful obedience to their superiors, and scrupulous precision in making observations, and fidelity in, and care in, recording them. They were all good computers, and much attached to the Department. ... Officers in charge...will consider it their duty to maintain the same high standard among the young men recently entrusted to their care. The sub-assistants, ... being generally very young and...unformed in character, require to be treated with indulgent consideration, but any defect in their dispositions or morals should be pointed out to them in a kind manner, and they should be kept strictly at work[3].

He writes to similar effect to Du Vernet who was recruiting from Mussoorie ;

> If you are able to obtain two good candidates from Mr. Mackinnon [IV, 166 n.5 ; V, 422, 436] it will be necessary, in addition to their careful professional training, to exercise a supervision and control over their equipments and private expenditure for at least 18 months. ... In the

[1] DDn. 652 (151), SG. to Mil. Dept., 27–8–44 ; DO., 19–5–45. [2] DDn. 493 (183), SG. to Peyton, 3–3–49 ; appt. from 12–5–48 ; Mil. Dept., 17–3–49. [3] DDn. 499 (134–6), 15–1–46.

case of mere schoolboys a parental supervision...is appropriate and desirable, because if young boys get into difficulties at starting, their...efficiency for life is endangered[1].

In 1847 he obtained authority to add one more assistant to the strength of each field party which, with the restoration of the post of Chief Civil Assistant, brought the full strength up to 30, and in 1850 authority was obtained for two extra assistants for Robinson's new topographical survey in the Punjab ; "the numerical strength...of the Trigonometrical Survey having been framed on a scale barely adequate for the duties of the Department. ... There are at present no less than 3 vacancies...in my establishment"[2].

All recruits had first to pass a written examination in drawing and mathematics, the results of which were passed to the Surveyor General. On appointment as 3rd class sub-assistant each one had to sign an indenture under which he bound himself to remain with the Department for a period of three years under penalty of forfeiture of one half of all the allowances he had received. He further engaged never at any time to resign during the field season [IV, 394].

In 1854 the terms and salaries of the senior selected posts were revised. Armstrong and Lane became Civil Assistants, Great Trigonometrical Survey—Clarkson, Keelan, Mulheran, Nicolson, and Rossenrode, Civil 2nd Assistants, the inferiority implied by the term "sub-assistants" being thus avoided [406].

In 1855 six more sub-assistants were authorised on the ground that four of the civil staff were now holding executive charges, and that Hennessey had been withdrawn to headquarters to replace the Astronomical Assistant [343]. This brought the strength to 36 excluding the two that had been sanctioned for Robinson's topographical party[3]. Both Robinson's and Du Vernet's party in the Himālaya had been staffed from the trigonometrical surveys, and this continued for the Kashmir Survey also, so that many of the assistants recruited for the G.T.S., now became excellent topographical surveyors.

Waugh comments on the keen competition for technical staff put up by Public Works, Railways, and other departments ;

The Trigonometrical Survey is one of the few departments which trains up and educates its own members professionally. ... The candidates are admitted at an early age after passing a severe examination. For two years at least they merely learn practical business. ...

Other departments are glad to take men from the Trigonometrical Survey, and many of those who have left us have risen to high positions and emoluments elsewhere. ... Last year the Trigonometrical Survey lost ten assistants from various causes. ... One of my most experienced civil assistants was offered a Government salary of Rs. 650 per mensem, though his pay with us was only Rs. 320 [Belletty]. That this brilliant offer was declined...is a remarkable instance of disinterestedness, illustrative of the strong attachment felt by the members of the Trigonometrical Survey to the Department [405]. ...

The salaries of the G.T. Survey were originally fixed at a time when less liberal notions prevailed, and the standard of education was lower. ... We have, therefore, a great deal to contend against. ... At this moment the Railway in Sind offers salaries of 300 to 500 per mensem to assistants receiving only 140 to 170 rupees in the Trigonometrical Survey, and two have already signified their intention to resign [Burt and Smith, 404][4].

He pressed the situation on the notice of Government ;

On account of the improvements which have of late years taken place in the emoluments, prospects, position, and standing of uncovenanted servants in every other branch of the service without corresponding advantages in the Survey Department, there is a natural tendency... among the members of the latter to better themselves elsewhere. ...

From the excellent training and education obtainable in my Department, there is a competition to obtain members of the G.T. Survey. ... Young men who have not given satisfaction in my Department...have immediately obtained higher salaries elsewhere. ...

Mr. James who...was...recommended for promotion—before that promotion could be sanctioned—was offered a Deputy Collectorship in Bundelkhand, being an immediate advance from Rs. 170 to Rs. 250 per mensem, besides better position and prospects. He immediately persuaded his brother, Mr. Joseph James, ... to join him [211, 414, 431].

[1] DDn. 524 (31), SG. to Du Vernet, 12–6–47. [2] DDn. 549 (19), SG. to FD., 4–9–50. [3] DDn. 547 (352), SG to Mil. Dept., 10–7–55 ; GBO. Comp. M. 9/8. [4] DDn. 665 (63), SG. to DSG., 21–6–55.

There is an order of the Hon'ble Court of Directors against Departments competing against each other. ... No order...can apparently prevail because a man retained against his will cannot be turned to any good account [IV, 341–2]. ...

The Sind Railway (not a Government body) has advertised for surveyors, and offers... salaries of 300 and 500 rupees per mensem to men whose qualifications would not render them eligible at all for my Department. Within the last year my Department lost no less than 12 assistants, ... more than 1 in 3 of my whole establishment. ...

I had the honour to recommend...the advancement of Mr. Belletty to the next grade. That assistant will be the only one left with Lieutenant Tennant on the resignation of Messrs Burt and Smith. ... The effect...will be to raise his salary in Sind to Rs. 220 per mensem, which I trust will be sufficient. I am told that the Railway offers higher inducements...but I am not disposed to enter into a competition of this sort[1].

In spite of this continual wastage and competition the Department drew a steady stream of suitable candidates from the European and Anglo-Indian boys of the Calcutta schools and the hill stations. Thuillier had those from Calcutta examined by the Chief Computer and trained for some months in the Drawing Office. In 1861 he reported as Surveyor General that there was

no lack in Calcutta of well educated...youths possessing the desired qualifi cations. ... No difficulty will be found in supplying them from this quarter. ... It would be well...to avoid entertaining for the Department candidates who are deficient in...acquirements so essentially necessary to ensure a succession of good and able members of the profession. ... The Departmental test...must be maintained[2].

In spite of examinations and other precautions there were the few who failed to make good. Waugh comments on a rough sketch of approximate triangles with computations and notes, providing

a second instance of gross error in Mr. W. Dyer's work. He should without loss of time submit his resignation in order to prevent the painful alternative of my recommending his removal from the Department on grounds of unfitness. ... The case is one which can admit of no explanation, because errors such as he has committed could arise only from incompetence. A similar instance was previously passed over, in the hope that he would take pains to qualify himself, but the result...has only served to prove his want of ability to perform some of the ordinary duties of a sub-assistant in the G.T. Survey[3].

Good assistants were highly prized, and Waugh writes to Montgomerie when he was starting the Kashmir survey with Johnson and Douglas ;

I regard the civil establishment of this Department as pre-eminently entitled to gentlemanly consideration and respect from its connection with a great national scientific work, the attainments which the profession demands, and the confidential nature of its duties.

It has been my constant endeavour...to elevate the position of the Civil Assistants and to foster their self-respect. ... I have no doubt also that you will take every reas nable measure to ensure their comfort as far as practicable in carrying on their arduous duties, and secure for them the respect of the native establishment and people of the country. ...

Your senior assistant, Mr. Johnson, is a worthy, unassuming, and experienced member of the Department. ... Mr. Douglas, on the other hand, is young and inexperienced and will require careful training[4].

And on Montgomerie's return to Kashmir for the second season [221] ;

Last year the Department was so shorthanded that I was obliged to detach you into the field with a smaller establishment of civil assistants than the usual complement. In fact, you had only one gentleman of any previous experience.

I gladly embrace the opportunity which augmented means...afford to attach another sub-assistant, Mr. Beverley, to your party. This gentleman has served for upwards of a yearin my headquarters office, where he has earned for himself an excellent character for intelligence, zeal, official aptitude, good conduct, and pleasing address. ...

As to the position occupied by our civil establishment, ... they are entitled to the highest rank accorded to uncovenanted servants of Government, and on a full equality, therefore, with civil engineers and all members of highly educated professions.

I could have added more new hands, but by doing so I should only tax your training power and thereby retard rather than accelerate progress. When your present strength is trained and skilful...it may be desirable to augment your establishment further[5].

[1] DDn. 547 (352), SG. to Mil. Dept., 10–7–55. [2] DDn. 687 (65), SG. to Robinson, 7–8–61.
[3] DDn. 699 (205). SG. to Clarkson, 28–7–58. [4] DDn. 592 (152), 11–1–55. [5] DDn. 715 (125), 4–3–56.

On hearing that Johnson had had an accident, Waugh promptly ordered that George Shelverton should be sent up from the Jogi Tila series ;

• This will subject Mr. Shelverton to a double field season, but his zeal for the service is undoubted...and I rely with confidence on his good spirit and readiness. ... Mr. Shelverton's former experience in the North-West Himalaya series, and knowledge of the planetable, added to his general ability, rendered him the most suitable person for this emergency[1].

Fortunately Johnson's trouble was soon righted (hernia), and the Kashmir Survey was the gainer by Shelverton's posting.

It was indeed with the utmost difficulty that the Surveyor General distributed a fair share of trained assistants to the several parties, as he thus explains to Strange who was pressing for more skilled assistants on the Coast Series ;

When you were under Major Renny-Tailyour on the Longitudinal Series, ... I was able to give...the experienced...Messrs. Lane...[and] Rossenrode. All the rest were raw untrained youths—Haycock, Pierce, Burt, McGill. ... From time to time others were added, ... untrained or only partially trained. ... Of these four there is not one now on the establishment. The Longitudinal Series...has not added a single trained assistant to the Department. ...

The loss of trained observers during the last three years has been unusually great. ... I cannot admit that any urgent necessity exists for strengthening your party[2].

In his last report to Government before leaving India he reiterates that he had to contend against the greatest difficulties arising from the ever increasing demand for uncovenanted employees, which has...greatly embarrassed my management. Beginning...with the extension...in the Civil Service, it has increased with the accession of territory, ... the Punjab, Sind, Nagpore, Hyderabad, Ceded Districts, and Oudh, which opened out successively a wide field for new employment.

We...begin at the beginning, taking our candidates fresh from the best...schools, and training them to the special duties of the Department. By this training...they not only acquire a special knowledge and skill in their profession, but...qualifications invaluable in other departments in which higher salaries are obtained with less exposure and exertion. ...

There has never been any want of eligible candidates, although the standard of...entrance examination has been raised very high. Entering at so early an age, parents have been glad to put their sons in a profession where they will at once earn a livelyhood, receive good treatment, and become qualified by the training...for other better paid employment. ...

That many have remained faithful to their first profession is not surprising. These have been the best men ; giving satisfaction, they have acquired a love for the work, and...have adhered to the path...in which they are appreciated [381, 403, 409, 426, 437]. ...

I should now record the high state of efficiency and excellent conduct of the whole Department. The advanced state of education in India has enabled me to raise the tests of qualification on entrance. ... I have also introduced a rigorous system of qualification test for promotion in each grade. ... These measures have had the happiest effects on the character and efficiency of the Department[3].

ALLOWANCES

The scale of pay for sub-assistants of the Great Trigonometrical Survey had been sanctioned in 1821 on Lambton's recommendation [III, 325, 379] ;

Principal Sub-Assistant	*sicca* Rs. 400 ;	or Company's	Rs. 418 [IV, 329 n.4].
Senior selected	„ „ 250	„	„ 259-12-3
1st grade after normal 3 years	„ „ 170	„	„ 177-10-4
2nd grade after normal 3 years	„ „ 140	„	„ 146-5-7
3rd grade, on appointment	„ „ 107	„	„ 111-1-0

A post of Chief Civil Assistant on Rs. 600 had been added in 1832.

The rates covered expenditure on tents, transport, and horses. No extra travelling allowance could be drawn, even for journeys on transfer [IV, 173, V, 346–7, 375, 399]. For the North-West Himālaya series the Surveyor General obtained a special "mountain allowance" such as had been sanctioned for Hodgson and Herbert in 1817 [III, 346–7 ; V, 35, 347]. The sub-assistants had to

[1] DDn. 715 (134), SG. to TOM., 4–4–56. [2] DDn. 691 (94), 12–8–56. [3] DDn. 625 (5) ; Report 1856–60, 6–10–60 ; paras. 72–81, 92.

equip themselves for an expedition of 7 or 8 months...and be at all times prepared for daily marching in a wide country, as well as ready to encamp on the summits of lofty hills far away from...villages. ... The estimate amounts to Rs. 108 per mensem, and as the pay of a sub-assistant of the third class is only Rs. 107, ... it is clear that...the cost of travelling in the hills exceeds the salary, and in the higher grades it would absorb the greater part of the pay. ...

Sub-assistants on former occasions were allowed to charge the extra expense of transport in contingent bills, but I do not think that this plan is calculated to work well in an expedition of lengthened duration. ... I would, therefore, propose a Hill Allowance of Rs. 60 per mensem, in lieu of all claims for transport of baggage, hardships, and difficulties. ... This...leaves a balance of Rs. 48 to be defrayed by individuals out of their own salaries, and...the balance rather exceeds the nominal cost of carriage in the plains, as a sub-assistant generally marches with 3 camels, the monthly expense of which varies from Rs. 21 to Rs. 36.

If, however, the allowance be continued throughout the year it will tend to compensate the above defect, and provide also in part for the cost of equipment...suited to mountain service. ...

The 15 men kept up...on the proposed mountain allowance will be available for clearing jungle, ... cutting pathways, ... raising platforms, planting marks, and other duties. ... It will be my duty to see that the allowance is discontinued when circumstances no longer require[1].

The allowance was sanctioned and the Surveyor General found that other parties pressed for similar concessions. He recommended it for Robinson's party working along the Jammu border [210, 375], but not for the longitudinal series working through the Aravalli Hills of Rājputāna. Strange learned that Lane had drawn such allowance in Sikkim but Waugh emphatically declined to extend it;

The only case in which it is admissable is for parties employed in the Himalayas, who are ...obliged constantly to maintain a large establishment of coolies. Even for that part of the country I am doubful of the advantage of granting the allowance, in recommending which I was very much misled by Mr. Lane. It has been a fruitful source of difficulty, envy, and jealousy ever since, and I have determined not to extend the precedent, and most certainly not as far as the locality in which your party is engaged. ... The sub-assistants must...not expect...all the luxuries which are attainable only in level country.

After further correspondence, and special consideration of Rossenrode's work in "pioneering the way" across the desert to Sind, Government sanctioned a special additional allowance of Rs. 30 monthly to all the sub-assistant surveyors...with the Great Longitudinal series...for the time during which they may be prosecuting their duties in the desert waste of Rajputana and in Lower Sinde[2].

This allowance was later extended to the Bombay party for "Kutch and the adjoining tracts". It was later raised to "Rs. 60, or the same amount as the Hill allowance and Assam allowance", on the representation that the original Rs. 30 "has been found insufficient in practice"[3].

In 1858 an important concession was made which permitted an assistant to draw two months advance of pay when transferred "for the convenience of the public service", and that when directed to "join with the least practicable delay application will be made to Government for payment of travelling expenses"[4].

In 1854 the Surveyor General obtained sanction to the interpolation of an 'intermediate' grade on Rs. 220 p.m., to bridge the gap between the classes on Rs. 173 and Rs. 259-12-3. He further recommended reclassification of the senior posts to counter the drift to outside employment;

The scale...for the civil establishment...was instituted many years ago [403, 405]. ...

The change of designation of the higher grades from the term Sub-Assistant...to the title of Civil Assistant will be esteemed a great boon, indicative of elevation in the social scale. ... This title also leads gradually to the highest title of Chief Civil Assistant. ... It will produce a good effect by...encouraging self-respect and a feeling of proper pride [403, 403]. ...

Many of the senior assistants...have now served upwards of 22 years, and more than half that time without any increase. ... It might be arranged to improve their condition in this respect without materially augmenting the present expense. ...

It was originally designed that each survey or series should have a commissioned officer at its head, but practically the Department has always been under-officered, and...three or more

[1] DDn. 524 (49), SG. to Mil. Dept., 12-2-47. [2] DDn. 616 (106), SG. to Strange, 7-10-50; Mil. Dept. to SG., 27-1-53, 616 (221); cf. DDn. 642 (535), Fin. Dept., 6-10-60. [3] DDn. 547 (352), SG. to Mil. Dept., 10-7-55; DDn. 718 (18), reply, 16-2-56. [4] DDn. 715 (349), DO., 24-2-58.

parties have generally been...under the charge of the senior members of the Civil establishment. In the year 1844 a charge allowance of Rs. 100 per mensem was sanctioned as a remuneration, ... which was considered a temporary command allowance [429][1]. ...

At the time, ... the Department, with the exception of the Bombay branch, was concentrated in the Lower Provinces, ... and when a charge fell vacant I had no difficulty in assigning it to the assistant whose claims were strongest. ... The surveys are now dispersed from Assam on the east to Peshawar on the west, and to Karachi and Cuttack on the south. ...

I have always made it a principle...that in each quarter there should be at least one Civil Assistant at hand, a good observer, fit to take charge in case of accidents[2]. Consequent on the dispersed state of operations...it will become embarrassing to arrange the charge of a series with due regard to seniority or other individual claims on the one hand, and without loss to Government on the other. A temporary vacancy...may occur on one side of India, while the senior Assistant having claim to a charge may be with a party on the other side. To transfer him for a temporary purpose may be a great inconvenience. ... His services may be specially required with the party to which he stands attached.

During a long journey from one side of India to another, his services are lost for many months. ... The loss of the charge allowance may appear a hardship to the senior. ... To prevent embarrassment, ... the allowance of 100 rupees hitherto drawn by Civil Assistants in charge, is...abolished from 1st November 1854, and in lieu thereof the pay of the 7 senior Civil Assistants is augmented by fifty rupees per month. ... This increase of salary is to cover all claims whatever on account of charge allowance[3].

The classification and salaries of the Civil staff now became ;

Chief Civil Assistant	Rs. 600	Senior Sub-Assistants		Rs. 215
1 Civil Assistant	400	1st class	,,	173
2 Civil Assistants	350	2nd class	,,	140
4 Civil 2nd Assistants	300	3rd class	,,	107

Civil Assistants are eligible to be regularly appointed by selection to the charge of a Survey. On being so appointed the Civil Assistant will receive a salary of Rs. 450, and after his first season's approved good service, he will be entitled to the full salary of Rs. 600 per mensem with the title of Principal Civil Assistant[4].

In 1860 the Surveyor General recommended special allowances that would bring the pay of his senior civil officers more in line with that of his military surveyors, and of uncovenanted officers of other departments of similar standing ;

In the year 1856 the new code for the Public Works appeared in which a new principle was adopted in regard to the salaries of civil engineers. Formerly a civilian...received...an amount equal to the staff allowance only of military incumbents. By the new rules they were entitled to an amount equivalent to the combined military pay and staff allowances. ... In this Department the inequality now existing...must...deter candidates from presenting themselves. ... I...recommend, in justice to my...civil assistants of the Survey Department that they should be admitted to equal privileges and prospects. ...

I would recommend that the Civil Assistant Mr. Hennessey, who is on the same footing as the military officers, should now receive Rs. 250 per mensem in addition to his present salary, whereby his salary would be equivalent to that of a Lieutenant holding the same office, and... he should also have a prospect equivalent to the pay of a Captain with staff salary of a 1st Assistant after 5 years further service.

For the Chief Civil Assistant I would recommend the pay of a Lieutenant. For the 3 Civil Assistants and extra Civil Assistant I would recommend Rs. 200 in addition, being equivalent to the pay of an Ensign, and to the 3 Senior Civil 2nd Assistants, including Mr. James, acting Chief Draftsman, I recommend an addition of Rs. 150. ...

These recommendations are urged on the grounds of equalising the prospects of the Survey profession with that of the D.P. Works and other branches of the Government services. ...

Besides, ... while high travelling allowances are passed to the members of the Civil Service and D.P. Works, the members of this Department, who are so much more under canvass, receive none. The rates ruling in other departments are 5, 4, and 3 rupees a day. To place my Department on a footing of simple equality the same rates will be necessary[5].

Government refused to make any increases that would involve increase of expenditure, and the Military Auditor General pointed out that the salaries had

[1] BMC. 24–5–44. [2] DDn. 547 (257), SG. to Mil. Dept., 1–9–54. [3] DDn. 600 (82); BMC. 30–9–54 ; DO., 25–10–54. [4] DDn. 547 (363), SG. TO AGG. CI., 30–6–55. [5] DDn. 594 (361); 852 (5), Report 1856–60, SG., 6–10–60, paras 83–6.

been fixed in 1833, not in "ancient times" [376, 383, 399]. The Surveyor General retorted that the order of 1833 merely confirmed the old salaries which dated from Lambton's days and added the post of Chief Civil Assistant ;

In fact, the salaries were virtually reduced 4½ per cent by the substitution of *sonat* for *sicca* rupees [1 : 274, n.3], and therefore, *pro tanto*, actually stand lower than in anoient times. In 1833, ... although that was a period of great retrenchment, it was admitted by His Excellency Lord William Bentinck that the salaries of Surveyors were already so low that no reduction could be made. They were, therefore, left as they had been first fixed.

It was not until a little after 1833 that the competition began from which the Survey Department has continued ever since to suffer [403–4]. ... Seeing the reality of this competition in the market for educated labour, the Civil Service and Departments...have all raised their terms, while the Survey alone remains nearly in its primeval state as regards salaries [399]. ... No less than 35 secessions have taken place of experienced hands, the result being retardation of progress and increase to the real cost of the work. ... The...Principal, Roorkee College, states clearly...that none of its students would take service in the Survey Department because the pay and prospects were...inadequate. ...

I would...offer my respectful advice that the arrangement...of extending the hill and equipment allowance to...the Department generally should be sanctioned...to prevent secessions[1].

By 1862 these recommendations had been sanctioned, but the equipment and hill allowances had not been extended to the whole Department[2].

In June 1862, the first twelve of the civil establishment stood thus ;

C. R. Lane	Chief Civil Assistant	Rs. 600	H. R. Duhan	Extra Civil Assistant, Personal Assistant to STS.	Rs. 370
J. W. Armstrong	Civil Assistant	450	J. Da Costa	Civil 2nd Assistant	302–12–3
W. H. Scott	Chief Draftman, Dehra Dūn	450	G. H. W. Shelverton	,,	309–12–3
R. Clarkson	Civil Assistant	400	N. A. Belletty	,,	309–12–3
J. O. Nicolson	,,	450	C. J. Carty	,,	339–12–3
W. C. Rossenrode	,,	373	W. H. Johnson	,,	309–12 3

There were also 30 sub-assistants drawing from Rs. 107 upwards [405].

In 1854, following the death of George Logan, Hennessey was advanced to "the senior division" as 2nd Assistant, and again in 1858 to 1st Assistant. Two years later Henry Keelan also, who had been permanently appointed to charge of a party, was advanced to the full status of 1st Assistant to fill the vacancy caused by the retirement of Major Strange. Waugh thought the younger military officers were as yet too junior for promotion from 2nd class,

and it is found inconvenient to have several officers nearly of the same standing. ... I think it would be a good opportunity to afford some encouragement to the Civil Assistants...by transferring this vacancy to that branch. ... I have shewn the great discouragement the Civil Assistants have experienced on account of the inadequacy of their salaries, and the great expenses they are subjected to in constant travelling. At the same time several...hold charge of series, and perform all the duties entrusted to military 1st Assistants in such commands.

Mr. Henry Keelan, in particular, has held charge of a party for several years, during which he has distinguished himself by his ability, zeal, and judgement. Indeed, he has given me so much satisfaction as an observer and successful triangulator that he has been employed in the most important operations and highest class of observations. He is now conducting the Rahoon meridional series, a charge precisely analagous to that held by military 1st Assistants. ...

I...recommend Mr. Henry Keelan for promotion to the vacant situation of 1st Assistant, to which a salary of Rs. 618 per mensem is attached, and I would recommend Mr. William Charles Rossenrode, a most able and distinguished 2nd Assistant of 22 years standing, for promotion to the grade of Civil Assistant on a salary of Rs. 373 per mensem, which will be vacated by Mr. Keelan's advancement.

The measures will in no way increase the present cost of the G.T. Survey, while they will be most beneficial to the Department on account of the encouragement they will give to the meritorious and hard working civil establishment[3].

This advancement of specially selected civil assistants to equal departmental status with military commissioned officers had indeed a most wholesome effect on the civil staff. However humble the role of the junior sub-assistant, he now had some hope of rising beyond the subordinate grades. The opening up, however, of

[1] DDn. 2 (151), SG. to Mil. Dept., 17–10–60. [2] Travelling allowance followed under FD., 22–4–65 [376]. [3] DDn. 2 (185), SG. to Mil. Dept., 4–3–61 ; new organization civil staff under Notfn. of 22–9–66.

such opportunities sometimes led to complaints, and there were from time to time occasions when an old and tried civilian resented a charge being given over his head to a young and inexperienced military officer. The Surveyor General had to remain the sole judge.

WORK

Whilst the officer in charge of a principal series was responsible for the lay-out of triangles and selection of stations—made all "final" or working observations—and took a leading part in computations—he allotted definite tasks to his three or four assistants. To the most experienced it was usual to entrust the approximate series in advance, which involved the selection of stations to form symmetrical triangles, and the observation of sufficient angles to give approximate positions. One or more assistants were deputed to clear the rays, build platforms and towers, and conduct minor or secondary triangles, either for ray-trace lay-out, or for the fixing of secondary points [98–113, 117–20]. It was the general practice to employ the last-joined assistant as recorder and observatory assistant, and the officer in charge was thus able to train him personally in the elementary duties of observation and recording, the various processes of taking out the angles and computing, and care and maintenance of instruments [116–7].

The Surveyor General writes to Hill on his taking over charge of the Coast Series with four assistants [22] ;

The senior of these, Mr. Clarkson, bears a deservedly high character for...skill in his professional duties...and uniform success in all his undertakings. ... During the last year and a half he had the honour to conduct the Maluncha meridional series under peculiarly arduous circumstances, and acquitted himself...to my entire satisfaction [14]. Although suffering from illness himself, and with the greater portion of his establishment prostrated, ... he persevered with unflinching constancy until he carried the series beyond the region of pestilence and disease. ... In all cases of difficulty you will find him like an additional right hand [415–6]. ...

Messrs. Kirwan and James [W.R.N.] have both served some years in the department, and have acquired a practical knowledge of several parts of their duty, so that you will find them immediately available for work. Mr. Lawrence has only lately joined, but...under able guidance and tuition promises to become an efficient servant of the State. ... You will pay the greatest attention to...these young men, with the view of their being fully trained up in every branch of their profession, and instilled with good principles and habits. ...

Keep your sub-assistants fully informed respecting all your movements and intentions. Without a clear knowledge and conception of your plans they cannot co-operate with you effectually, ... nor can they...work zealously and judiciously in furtherance of the...work. It is more particularly your duty to keep your senior assistant apprised of your plans and intentions, so that in case you yourself fall sick, he may be able to carry on the work systematically without undoing or redoing any part. ... During the past season all your sub-assistants seem to have been kept in profound ignorance of your...intentions[1].

In approving Du Vernet's proposal to leave his sub-assistants at Allahābād whilst the rest of the party moved to Dehra Dūn, Waugh expressed sympathy for their request to be left in comfortable quarters during the rains [366, 368] ;

Their prayer is a very reasonable one, and...they are entitled to much consideration after so many years of toil and privation, and more particularly after so successful a performance as that of last season, which could not possibly have been brought to a satisfactory conclusion without extraordinary exertions, zealously and heartily rendered. ...

Mr. Mulheran is more particularly deserving of consideration, as he has invariably been associated with success [416]. ... I am very glad that it is in my power to comply with their request without injury to the public service. ... I have that confidence in the sub-assistants of the G.T. Survey as a body that I am persuaded they would, when called upon, make every personal sacrifice for the honour and success of the Department, and willingly follow their officers through any dangers and difficulties. No class of men in India go through more hardships and privations, and none are more cheerful, ... obedient and loyal[2] [381 ; t-page].

[1] DDn. 600 (194), 1–9–45. [2] DDn. 492 (81–5), 8–7–47.

Armstrong had been a first class surveyor in his younger days but lost energy as he grew older [415]. He could certainly write an amusing letter, such as the following to Logan from the Hurilaong series in March 1849 [13] ;

I have but a short time ago returned from a...fatiguing minor survey which had kept me from camp and its little comforts from sunrise till near sunset. ... The Hurilaong series somehow is fated to labour under difficulties. ... Not only has Terry left me, but Mr. Belletty has thought proper to fall ill too, and is gone off to Benares for medical aid, whilst I am left alone unscathed by any complaint but that of being actually "three persons rolled into one", a corporation which it requires time to see whether my slim figure will be able to carry.

I have lately often wished I had a baboo like yours to assist me, and I will try my best now to procure one to do some of the drudgery of the office, and a little, even, of the observatory work. ... I am thinking how I shall manage to get through my azimuthal observations next month alone. ... If the worse comes to the worst I shall make bold to become acquainted with some of the Christian planters hereabouts, and get one of them to lend me a hand. ...

About John Rossenrode coming out to me, I must cry "pardon" with the best grace I can, for I shall never be able to manage him if you have failed. There was in your treatment of him as much of kindness and conciliation as should have made even his incorrigibility good, but he seems quite impervious to such treatment. ... I should think Capt. Du Vernet's series would just do his business for him one way or the other [413].

I should think you will complete a good portion of the North Longitudinal series by the time you close work, and it is likely you will have Masuri for your quarters next rains. Crippled as I am, I would have much liked your coming here where we are to canton, for more reasons than the advantage of having your advice in...my computations.

I have doubts whether Terry will go to the Hills for change of air. ... The long period (10 months) he proposes being absent...is to be on full pay for 3 months, and should his...health require a prolongation of leave he will get it on half pay. Now, Terry is such a spendthrift that half-pay will never do for him in...Masuri, and I should not wonder if he is driven to return to the series from Allahabad after his three months are out. ...

I have three more hill stations and four tower stations to observe at before I close this season. ... The Soane is a great bother to me on account of its sands, and already the drifts when the wind blows are anything but adapted for long views. ... However, ... there are hopes of some good change in the weather between this and May next.

Pray remember me to the johnny's with you. I am sorry to hear of poor Hennessey having been ill. He is a good boy, and though he is either too lazy or too busy to writé to me, I have...much anxiety on his account[1].

It took Hennessey several months' leave to recover his health, and he was ill again when on minor triangulation in the Punjab two years later [37] ;

For now nearly three months...I have been suffering most cruelly from ill health, until at last my existence has become perfect misery, ... and this though I have denied myself every indulgence. ... The irregular and trying life I lead nullifies the effects of both care and medicines. ... I...beg to resign my situation in the Great Trigonometrical Survey of India. ...

I have struggled on thus far, enduring misery that might be deemed fabulous, and...will I hope be able to conclude the survey of the Ravee at Lahore, beyond which the effort...would be both bootless to the public service, and deeply injurious to my health. ...

Though the exposures to the...pestilential tracts of country, and inclemencies of weather... have reduced me, at my early age, to...a confirmed valetudinarian existence, I cannot cease to remember with feelings of emotion the Department to which has been devoted an entire stage of my life, ... from my boyhood to my prime[2].

He recovered his health and stayed on happily in the Department ; with sedentary employment at Dehra Dūn and Mussoorie [343–4, 416–7].

Thorough training was of the utmost importance, and during the recess season of 1855 Strange, as Astronomical Assistant, was directed to initiate

the young gentleman at headquarters recently admitted to the Department[3]...into the rough adjustment, use, and maintenance...of the vernier class of theodolite, from 5 inches to 14 inches in diameter. ... The class...will meet...twice in a week, say Monday and Thursday mornings, weather permitting, or...in the afternoon...in the observatory [138, 343][4]. ...

Married men were not welcomed as 3rd class sub-assistants, and the Surveyor General writes to Paschoud, whose married state had not been disclosed ;

[1] DDn. 504 (187), 11–3–49. [2] DDn. 509 (229), 27–1–51. [3] Beverley, Masters, Ryall, Neale.
[4] DDn. 14 ; 11–6–55 ; Waugh MSS. II [98] ; Heads of Lecture, Vernier Theodolites.

My objection to married men entering the Trigonometrical Survey are founded solely on a consideration of the difficulties which persons so circumstanced experience in maintaining themselves...on the salary of the junior grade ; added to which it is also difficult for them to devote their whole attention to...their duties. ... I could not conscientiously have recommended your appointment if I had been previously aware that you were a married man.

Now, however, that you are a servant of Government, it would not be proper to allow any private circumstance to influence my opinion of your...discharge of your duties. ... If it is your wish to resign, ... make a formal application[1].

Paschoud resigned the following month but was re-admitted later in the year after further examination in mathematics ; the Surveyor General consented "to overlook the past". Five years later Paschoud took his own life.

We may here note the monthly budget put forward by an Assistant Revenue Surveyor who was pressing for promotion from a salary of Rs. 150 p.m. ;

My family at present consists of my wife, self, and child 12 months old, and I expect an increase before two months expire. I have...inserted every item of monthly expenditure, and you may object to some of them, such as brandy and wine, and cigars. ... The labourer who earns a shilling a day spends his penny to raise his spirits after the toil of the day, and not possessing the means to drink beer or wine, I use spirits. ... I...dare not deny my wife the common necessaries of life when she did not want a few of the luxuries before she married.

To my aged grandmother	Rs. 10	Cook	Rs. 5	Sweeper	Rs. 4–8	
Subscription for my wife	,, 10–14	Ayah	,, 5	Chowkidar	,, 4	
Khitmutgar & Bearer	,, 6	Washerman	,, 6	Waterman	,, 4	
	26–14		16		12–8	55–6
Table expenses, including sago, etc., for child, tea, bread, and butter					... Rs.	30
House Rent, at an average the whole year round					... ,,	30
3 bottles of brandy ; 60 cigars, and occasionally a bottle of sherry ...					... ,,	8
Amount of salary ,, 150				Total Rs.		123–6

When 30 rupees are mentioned as house rent the whole year round, travelling expenses whilst in the mufussil are included[2].

Protest against Sunday work was occasionally raised as a nuisance value, rather than with any genuine conviction [IV, 378, 395], and Waugh thus states the case for G.T.S. parties treating Sunday as a working day during the field season ;

The practice dates from the origin of the Great Trigonometrical Survey. From the nature of the climate, ... the duration of the field season is...more or less limited, and it is sometimes extremely dangerous to prolong the stay of a party in the field. For this reason it has always been an object not to lose a single day in the field lest the health of the party should suffer. There are many instances on record of serious consequences ensuing from the loss of a single day. Mr. Joseph Olliver...was detained a month at a station to complete a single set. ...

The institution of the Sabbath was introduced as a day of rest for man and beast, but during the course of the field season there are many days when halts are compelled by reason of hazy weather and other circumstances. There is, therefore, usually no urgent want of rest. On the other hand there is no possibility of attending church on Sundays in the jungles, while the duties executed...need not in any way interfere with private devotion.

The business of the Trigonometrical Survey in the field is not a matter of routine like ordinary land surveying, or...office work. ... Our work is dependent on climate and weather and can only be carried on successfully by availing oneself of favourable opportunities. ...

The G.T. Survey is not a solitary instance of such works of necessity being performed by Christians. Ships are worked on Sundays, and observations are taken for the purposes of navigation, ... as well as ordinary domestic duties in every day life. ... No necessity can be greater...than that of withdrawing a party as speedily as possible from an unhealthy tract. ... The average field season is 7 months ; on the Coast Series it is less. But it is easy to calculate that if one day in seven were wasted in idleness, the party would be detained in the field nearly a month longer, to the prejudice of their health[3].

On the Madras revenue survey Priestley protested without avail against a Government order forbidding Sunday work. He feared

that the annual outturn...would thereby be reduced about 150 square miles for the whole number of ameens, and that the rest on Sundays would only afford the latter an opportunity

[1] DDn. 499 (287–8), 13–1–45. [2] DLR. 36/31 (87). Wm. Heysham to DSG., 29–3–45. [3] DDn. 591 (88–7) ; 598 (188), SG. to Clarkson, Coast Series, 18–9–51.

of quitting their work, and going about to see their friends at a distance, the fatigue of which would unfit them for the next day's work[1].

MISCONDUCT

Since the great majority of the civil assistants were recruited as schoolboys of 14 to 16 years of age, it is not surprising that there were occasional instances of misbehaviour. A very small number turned out to be thoroughly unsatisfactory, either from idleness or persistent lack of discipline. These young men, as well as those unsuited to the work in a professional way, were generally recognized in the course of the first year or two and discharged, or persuaded to resign. No officer who had but three or four assistants could tolerate continued idleness, misbehaviour, or ineptitude of one of them. Provision was made for such early weeding.

Young men from city life, especially life in Calcutta, were seldom suited to the hard life of a surveyor in the jungle, and Waugh writes from Calcutta ;

Leave of absence is always injurious to the interests of the Department, and I am...reluctant to grant it, but more particularly to visit Calcutta, which is the very last place I should ever wish a surveyor to come to. A short residence here is utterly destructive of all the good habits of our Department, engenders luxurious taste and expensive habits, whereby a surveyor is rendered thoroughly inefficient. The people here are a poor set compared with our manly and vigorous...sub-assistants, who are certain of corruption in such a place[2] [438].

A taste for expensive living was sure to lead to trouble, to the borrowing of money and the burden of debt. The borrowing of money from the money-lending caste of *khalāsis* was a particularly objectionable offence, to be severely punished [IV, 374]. The brightest and most intelligent boy could never make a good worker in the wilds if he was always hankering for the fleshpots, or worried by debt ; "those who do not practice...self-denial can never expect to rise to stations of confidence"[3].

Lack of discipline was particularly undesirable in a small unit such as a triangulation party, where strenuous work and constant fever under solitary conditions in the wilds would often lead to frayed tempers. Reginald Walker, but recently given charge of a party, reported George Terry, his senior assistant of 14 years service, for insolent behaviour, submitting "voluminous correspondence" that had passed between them. Waugh had much regard for Terry but could not overlook such misconduct ; he writes to Walker ;

Mr. Terry...has taken offence at your treatment of him from the very beginning ; ... after brooding for months over slights...either fancied or real, his temper got the better of him. Mr. Terry has served 14 years in this Department ; ... his conduct has been invariably correct, his demeanour respectful, and his character strictly honourable. Although he has...for the most part been employed under my own orders, he has also served under Captain Renny and Mr. Logan, and we had only one opinion of him. ...

He has no valid reason to object to the style of your letters ; ... even admitting all he advances, still it cannot justify...his disrespectful behaviour. ... I have therefore...removed him to the Gurwani Series, in which party he will be placed under a senior sub-assistant and... stand 2nd instead of 1st. ...

Although...Mr. Terry has no right to complain of the style of your letters, ... they appear to me...to be needlessly dictatorial in tone, and verging...upon the bounds of civility. ... I think so dictatorial a style is inappropriate as addressed to civilians, and more particularly to the sub-assistants of this Department, who as a body are...remarkable for their correct behaviour and loyal disposition. ... The rule in this Department is that the simple expression of a wish on the part of a superior is considered tantamount to an order. ...

Idleness...could only have been temporary, and consequent on the very hard labours previously undergone—a relaxing of a bow long stretched. Considering the quantity of work executed by your party last season, it is clear that all must have worked hard[4].

Waugh at the same time reproved Terry for "a very improper display of temper" ;

[1] *Mad. Sel.*, LXXIV (185), 31-8-59. [2] DDn. 496 (252), SG. to Logan, 20-5-44. [3] CL. 25-3-36 ; DO. 27-12-44. [4] DDn. 492 (99-101), 16-7-46.

You say that Lieutenant Walker never behaved towards you in the same kind manner that you were treated by Captain Renny or Mr. Logan, or myself, but was it reasonable...to expect the same...consideration from a perfect stranger as from those with whom you have for years been intimately associated ?

I knew you as a little boy of 14 years of age, and you have grown up to manhood under my eye. You have accompanied me in many wanderings, and we have passed together through several eventful...scenes ; ... we have treated you more as a parent would a son. ... You cannot reasonably expect the same...indulgence from a perfect stranger. Lieutenant Walker knew you only as his head assistant. ...

Let us hope that under Captain Du Vernet you will shew that your former good conduct was not merely the result of serving under certain officers, ... more their merit than your own[1].

Two years later Terry got into trouble through twice assaulting villagers in the Gorakhpur District. This was reported by the N.W.P. Government and the Government of India ordered his dismissal[2].

Amongst the very few individuals of quarrelsome, turbulent, disposition were John Rossenrode [IV, 345]—son of that excellent surveyor, William, and brother of the equally valued assistant William Charles [416]—and Charles Olliver, son of Joseph, who had so long and distinguished a survey career [III, 491].

Waugh describes John Rossenrode as an inveterate grumbler and serious trouble-maker, with an "intriguing and discontented spirit, ... the moving spirit of evil in my camp". He passed him over for promotion in 1850 and transferred him to the Bombay party from which he resigned in 1852 [103, 193]. Thirteen years later Rossenrode begged without result for re-employment ;

I have passed from loving the ways of folly, sin, and death to that of virtue, light and life, and, thinking that...I may be enabled once more to fill a post in the Great Trigonometrical Survey...usefully, and so return to my old profession...to end my earthly labours. I am a family man of wife and three children[3].

Charles Olliver was responsible for trouble in the Coast Series under Clarkson, and the Surveyor General noted that his manners had never been good ;

During the cold season of 1848–49 he was...with Captain Du Vernet's party in the Kohistan Jalandar, and...happened to fall into the hands of the insurgents by whom he was detained about a week [35, 474]. ... Beyond the inconvenience and discomfort incidental, ... I am not aware that he suffered in any way, and for the loss of his baggage he received compensation. ... The whole adventure seems to have had the bad effect of turning his head, so that from this time he began to consider himself a hero of romance. ...

During the ensuing season of 1850...Sir Henry Lawrence, K.C.B.[4], President of the Board of Administration [272 n.3], happened to be passing that way, and called at the sub-assistant's tent, ... making enquiries about his work. Mr. C. Olliver, far from appreciating the condescension of the Chief Authority in the Punjab and rendering the information sought for, was uncivil and disputed Sir Henry's right to interfere. ...

I need hardly add how deeply mortified I felt on learning that a member of the Department under my control...had been guilty of gross disrespect towards a personage of Sir Henry Lawrence's high position. ... Mr. C. Olliver being at that time at my headquarters, I sent for him and recommended him to make a written apology. This he positively declined to do.

The official complaint made to Du Vernet from Lahore stated that

the President of the Board observed that Mr. Olliver...had...permitted to be cut almost the whole of a peepul tree close to his tent. ... When reproved for so offending the prejudices of the people, Mr. Olliver, instead of expressing regret, was disposed to be uncivil ; on which account the President desired the tehsildar who was present to report the circumstance to the Magistrate of Kangra. ... A person who would wilfully destroy a peepul tree for fodder for his cattle...is likely enough to commit other outrages on the feelings of the people[5].

Olliver was thereupon transferred to the Coast Series, and shortly afterwards started writing a series of anonymous letters impugning the work and character of Hill, the officer in charge. The authorship of these letters was firmly pinned on him, and in view of his generally insubordinate behaviour he was requested to resign, which he did during 1852[6].

[1] DDn. 592 (94), 16-7-46. [2] DDn. 499 (349), Mil. Dept., 19-3-50. [3] DDn. 103 (107), to STR., 1-7-65. [4] an old revenue surveyor [IV, 452-4]. [5] DDn. 526 (264), Sec. Bd. of Admin., 15-4-50. [6] DDn. 542 (272), SG. to Mil. Dept., 27-11-51.

George Howard [431] was a more picturesque sinner. The local magistrate complained that he had ridden "furiously...on a large black horse through the town of Vizagapatnam, and evidently the worse for liquor, ...on Sunday afternoon". Howard replied that he was *not* intoxicated, but that the horse was a new one. A local tradesman complained that Howard had visited his house in a drunken state and demanded admittance. He threatened to beat the servant and enter the house with his horse. The animal came up two of the steps and backed, and "Mr. Howard made use of very improper language". Howard gave a lengthy reply written on black-edged paper, in beautifully neat handwriting. He resigned a year later[1].

SUCCESSFUL CAREERS

George Logan was quite the most successful of all the civil assistants of the G.T.S.; coming out to India in 1830 at the age of 21 he was fitted into a temporary post at the Calcutta observatory where he did so well that by 1843 Everest had given him permanent charge of a field party [IV, 380]. Without being a mathematician he had a flair for practical geodetic work, and produced results of the highest order. His organization and control worked smoothly and efficiently, and Waugh considered his party the very best training ground for his young officers, and Logan himself "a very valuable example to a debutant"[2]. His death in 1854 was a great loss to the Department and shock to Waugh personally.

William James and John Peyton had both been several years in the Department before Everest's return in 1830. James joined the Revenue Survey under Hodgson in 1821 [III, 363]; he was transferred to the G.T.S., in 1832, and did valuable work on the Budhon series and then on the Great Arc until given charge of the Gora series just before Everest's departure [IV, 376], but died the following year. Three of his sons followed him in the Department. The eldest, William Richard Nix, joined in 1841 and resigned in 1854 to join the provincial civil service as Deputy Collector at Jhānsi. John Owen Nix, appointed in 1845 [pl. 24], was an outstanding draughtsman who was of the utmost service to Robinson on the Rāwalpindi survey both in planetabling and mapping. In 1858 he was posted to charge of the Calcutta drawing office where he rose to become Assistant Surveyor General in charge of mapping. He retired in 1884 with the rank of Deputy Superintendent 2nd Grade. Another brother Joseph Arthur Nix was appointed to Robinson's party in 1850 but resigned in 1854 for the junior civil service [211, 403. 431].

Peyton, son of a Superintending Surgeon, had joined Everest at Hyderābād in 1823, and was under Olliver on the Calcutta longitudinal series. He was appointed Deputy Computer in 1832 and accompanied Everest up country, taking charge of all the computations of the Great Arc. After Everest's departure he was given charge of the Calcutta meridional series, on the successful completion of which in 1848 he was appointed Chief Civil Assistant. He was thoroughly reliable, and in 1852 Waugh was very glad to put him in charge of the East Coast series where the slow progress had given much anxiety. In acknowledging Peyton's application to resign three years later Waugh describes him as

> the only old and experienced member of the Department left to me in whom I can repose unbounded confidence. ... I repeat...the deep regret with which I personally look forward to... being deprived of...one of the most able of the executive officers of the Department. ... It will...be a pleasure...to report to Government on your distinguished career, ... and to represent the nature and extent of the services rendered by yourself over a period of 32 years uninterrupted by a single day's leave of absence[3].

Peyton retired in April 1856[4], and his nephew James, a fine topographical surveyor and draughtsman, served in the Department till 1886 [428].

[1] DDn. 687 (138), 18-11-61; 18 (132), srs. to SG., 29-8-62. [2] DDn. 452 (301-25), SG. to Mil. Dept., 22-8-45. [3] DDn. 592 (256), 24-9-55; Renny-Tailyour resd. 1853; Logan d., 1854. [4] DDn. 643 (5), SG. to Mil. Dept. 10-1-56; Govt. sanction, 20-3-56; DO. 619 (246); & 715 (145-7), 10-4-56.

During Everest's time Armstrong had held charge of the Ranghir series for considerable periods during Waugh's absence on the Great Arc [IV, 65–6]. He took charge of the Karara series from Shortrede in 1845, and of the Gora series from Garforth in 1847. He was then given charge of the Hurilaong series, on the close of which in 1852 he brought the party up to the Punjab [31–3, 52, 361]. Being dissatisfied with his work on starting the Jogi-Tila series Waugh withdrew him to headquarters at Dehra Dūn and then sent him to the Indus series in 1855;

It would have been more agreeable to my feelings to have spared a gentleman of your standing...so troublesome and expensive a journey, and I had, in fact, hoped to have the benefit of your...talent as a computer in the General Report [366], but...last year no less than 11 casualties occurred. ... I am therefore constrained to deprive myself of your services in order that an experienced civil assistant may be with the Great Indus party. ... I will recommend that you should be allowed a boat of 1,000 maunds to convey yourself and establishment at the public expense from Ferozepore to Kotri [48, 484][1].

The following year he decided that Armstrong would have to be passed over for the post of Chief Civil Assistant on Peyton's retirement [410];

The extreme amiability and gentleness of your disposition renders your private character estimable, while the talents with which you are endowed, and the acquirements you formerly cultivated, have been duly acknowledged and rewarded. Nevertheless, no one knows better than yourself that all these personal advantages...have been in a great measure rendered ineffectual by a fatal lethargy which...you have allowed to creep gradually over you, notwithstanding my repeated warnings, until it has...sapped your force of character, ... rendering you unfit for any position but one of subordination and mediocrity. ... Neither in the conclusion of Hurilaong meridional series, nor the outset of the Jogi Tila did you acquit yourself to my satisfaction[2].

Amstrong continued as assistant in various parties until he resigned in 1864.

Lane held charge of the Calcutta meridional series during season 1843–4, and then continued as assistant to Peyton. He took charge of the Maluncha series on Walker's death, and moved with that party to Rājputāna to work as senior assistant under Renny and Strange. To his petition for advancement to independent charge, Waugh commented that want of energy is

the weak point of his character, and perhaps the only weak point. His intelligence and capacity are undeniable, as well as the amiable traits of his disposition, which have always rendered him a valuable assistant to others, but when he is left to his own resources there is a want of spirit and activity, which throw a dull torpor over all his proceedings[3].

Lane took over charge of the 2nd Hill Series from Strange at Karāchi on 1st February 1955 [44], and started the Rahun meridional series the following season. In 1856 he was promoted Chief Civil Assistant [405–8], and then was transferred to charge of the Assam series, where progress had been held up by sickness.

Scarcely had I decided [writes Waugh] on Mr. Lane's deputation to Assam when Mr. Nicolson was compelled to apply for 12 months leave...to Europe to recruit his shattered health. ... Mr. Lane had now a trying task before him...—climatic and physical difficulties of no ordinary character...—reorganization of an establishment crippled by death and disease...—and he had to prosecute a long journey to the scene of operations. ...

I would recommend him...for an additional Rs. 268 per mensem to make his salary equal to that of a lieutenant in the Army, and 1st Assistant, G.T. Survey[4] [407].

Lane extended the series through Assam and southwards along the Eastern Frontier till 1865, and was then moved to the more comfortable charge of a levelling party till he retired on pension in October 1871.

Clarkson held charge of the Maluncha series at intervals from December 1843 till September 1845 drawing high praise from the Surveyor General [14, 409]. He was then transferred to the Coast Series as senior assistant first under Hill, and later under Peyton, Strange, and Basevi. He held charge at frequent intervals, and was considered " one of the...most accurate observers in the Department ". He was however, handicapped when holding charge by the poor work of some of his assistants—stations badly sited—towers badly built—insubordination [24–7]. He

[1] DDn. 592 (217) 3–7–55. [2] DDn. 691 (19), 8–3–56. [3] DDn. 616 (86), SG. to Strange, 21–8–60.
[4] DDn. 643 (237), to Mil. Dept., 30–7–58.

had hardly the strength of character to make a good leader, though he was a first-class assistant under a good officer. He retired during 1864 [22–9].

Henry Keelan was a first-class officer in every way, and had been one of Everest's most trusted young assistants on the Great Arc [IV, 384]. He particularly distinguished himself running a minor series of triangles though the tremendous Himālayan gorges of the Sutlej and Spiti rivers during 1851–2, and did good work in charge of a detachment on the Great Indus series, 1858–60 [48–9. 203–4]. He spent seasons 1860–3 on the Rahun series in Rājputāna, being promoted 1st Assistant on Rs. 618 in May 1861. He continued to hold charge of important parties till his retirement in 1875 at the age of 57 after special extensions of service. His son Henry Elliott carried on the good name for another twenty years.

James Mulheran had always done well in the triangulation parties, and brought himself to special notice by exceptional work on triangulation and planetabling in the high Himālayan regions of Kāngra and Chamba [202–8]. After holding charge for two seasons, he was transferred to charge of the topographical survey of Berār on the resumption of the Hyderābād survey in 1855.

A happier selection could not have been made. ... Mr. Mulheran has made himself exceedingly popular with the civil authorities, which his predecessor did not [178]. His work has thus been facilitated, whilst he has also rendered himself...useful...in many ways [268].

Mr. Mulheran's conciliatory and kind disposition endears himself to the natives, whom he manages with great tact, patience, and firmness. These qualities have enabled him to introduce largely native agency into this portion of the survey. ... By beginning cautiously with a few hands, and carefully instructing them in the field, Mr. Mulheran...has succeeded, and now has a party of six...at work under vigilant supervision [447]. ... From his long training on the Trigonometrical Survey he has been able to carry out the triangulation...in a style of accuracy not previously attained...by previous superintendents[1].

It was a fitting close to his life of service that in 1869 Mulheran should die in the course of a hard field season in Nirmul jungles on the Godāvari.

As assistant on the Calcutta meridional series Nicolson made a valuable survey of the Hooghly river during 1845–6 [15], and during 1849–50 he took over charge of Peyton's party on the N.E. longitudinal series and made the successful observations that established the position and height of Mount Everest [85–91]. He then held charge of the North Parasnāth and the Assam longitudinal series, till compelled by ill health to take furlough to England. On his return he held temporary charge of one of the topographical parties in Orissa, and between 1861 and 1863 was on special duty taking astronomical observations to fix the Cocos Islands north of the Andamans. He was then employed on the survey of "waste lands" in Assam and retired to England in 1865.

William Rossenrode, son of one of Lambton's trusted assistants, inherited his father's abilities as geodetic triangulator, and won a reputation for laying out the advanced approximate series [31, 99–100]. His line of triangles across the desert between Abu and Karāchi was particularly successful. From Sind he was transferred to the East Coast, Waugh writing to Strange that,

trained under myself and Major Renny-Tailyour, he attained at an early period to a very high reputation for energy, zeal, and skill in laying out approximate series, a branch of the profession in which his father before him was also deservedly celebrated [III, 499]. ... It is only...those who have themselves selected stations in difficult countries who can rightly estimate the immense advantage of having all this laborious and difficult part prepared...beforehand.

It was on account of his talents in this respect that I removed Mr. Rossenrode to the Coast Series which had hitherto languished for want of sufficient...aid of this very kind [27–8][2].

After two seasons valuable work on the Coast series Rossenrode was tranferred to Assam where his energy and drive did much to restore progress. He took over charge of the Frontier series in 1865, and later held charge of a party in the Central Provinces and the Nizām's Territories, till his retirement in 1876 [31–3].

Perhaps the most remarkable of all the uncovenanted assistants was John Hennessey, who joined the Karara series under Shortrede in 1844 at the age of

[1] DDn. 652 (5), SG. to Mil. Dept. 6–10–60 (para 57). [2] DDn. 592 (375), 1–12–55.

15 with but little knowledge of mathematics. He was then fortunate in having four years under Logan, though he became saturated with malaria. From 1849 he was transferred to the headquarter office at Dehra, and was some months on sick leave. He was again attached to Logan's party in the Punjab, and employed in surveying the major rivers [37, 273]. Being repeatedly ill, he was brought in to Dehra to understudy the Astronomical Assistant, and when Renny-Tailyour retired in 1853, he was appointed Personal Assistant to the S.G. for charge of computations [90, 343]. He here showed exceptional qualifications, and in March 1854 Waugh recommended his appointment as 2nd Assistant G.T.S.;

He has...devoted all his leisure time to the advancement of his studies, so that he has made considerable progress in mathematics and in general scientific knowledge. During the last two years he has served at my headquarters, where he has been employed in the most difficult calculations, in astronomical and other observations, and recently in...various scientific duties...in which he is not well versed.

Mr. Hennessey also possesses two qualifications which are rarely found in a high degree, and at the same time are of especial value in geodetical operations. He has a very rigorous sense of accuracy, and a most vigilant eye for the slightest error or mistake. In a work like the Great Trigonometrical Survey these qualities are of the greatest importance, and...should be fostered and encouraged. The same...merits would ensure...advancement in any other branch of the service and, as he possesses friends and relations anxious to further his interests, his remaining with my Department...depends on the prospects that can be held out to him. ...

I...recommend him...to be appointed a 2nd Assistant in the G.T. Survey. Although Mr. Hennessey is fully entitled to this recommendation on...his merits, ... it is a matter of great importance...to attach him permanently to my field office on account of...the retirement of several experienced members of the Department, and more especially that of my Astronomical Assistant, Captain Renny-Tailyour[1].

This promotion was sanctioned from 24th April 1854. During the next year he was largely employed on computing position and height of the snow peaks, and his pay was now raised to Rs. 400 a month;

Mr. Hennessey...has rendered himself exceedingly useful...in completing the computations connected with the two base-lines [Chach & Karachi], ... and is now engaged on the General Report of the N.E. longitudinal series, and in determining the elevations of the Himalaya mountains from Chumalhari in the east to Safed Koh in the west[2] [91].

In 1858 he was further advanced to be a 1st Assistant on Rs. 618 p.m.

In 1863, he took furlough to England and went to the Ordnance Survey at Southampton where he mastered the processes of photo-zincography with a view to the establishment of a press at Dehra Dūn [331]. He then spent several months "on a course of mathematical studies at Cambridge". On his return to Dehra he resumed charge of the computing office which had been brought up from Calcutta after the retirement of Radhanath Sickdhar [344], and with Herschel assisted Walker in the final reduction and adjustment of the triangles of the Great Trigonometrical Survey[3] [125]. He established himself as a geodesist of high standard and on Walker's retirement succeeded as Superintendent of Trigonometrical Surveys[4].

Of the younger assistants George Shelverton and Johnson did several seasons of hard mountaineering in the North-West Himālaya and the Kashmir surveys [202–3, 207–8, 222–36]. Shelverton joined in 1847 and after three seasons triangulating in Kashmir was given charge of the Gurhaghar series which he completed in 1862 [51]. He then held charge of principal triangles through the Central Provinces, the Nizām's Territories, and Godāvari District till his death in 1871. He had persisted through two seasons with constant attacks of malaria, and died in camp at the foot of a hill where he had been observing only two days before;

This was the region [writes Markham] in which Everest and his whole party were struck down with malignant malaria half a century ago [III, 229–32]. The country is densely wooded and is little better known than it was in the time of Everest, and has not yet been mapped. ... Mr. Shelverton and several of his men were struck down. ... He had a relapse and died in the midst of his labours a few weeks later[5].

[1] DDn. 547 (226), SG. to Mil. Dept., 23-3-54. [2] ib. (427), 16-11-55; sactioned, Mil. Dept., 29-11-55. [3] *GTS.* vols. I to VIII. [4] *DNB.*; *2nd Suppl.* (246-7). [5] Markham's *Abstract, 1869-70* (12).

Johnson joined in 1848, and with a few short breaks was planetabling and triangulating in the mountains till 1865. A year later he resigned his Survey appointment and took up service under the Māharājah of Kashmir [238].

Both William and Henry Beverley did fine work and held charge of parties on principal triangulation for several years, and both died in the midst of their labours, Henry at Shillong in 1880, and William at Poona two years later. Alexander Donnelly and Angelo D'Souza also rose to charge of field parties. The Bombay assistants, James Fraser, Joseph Da Costa, and Thomas Sanger did excellent work.

NOMINAL ROLL, 1844–61

Name, Birth, Death	Appointed[1]	Employment	Domestic
ANDING, Geo. Augustus b., Surat., 10–5–36.	21–10–59 Poona	Bombay, 1856 till resd., 1873.	son of Christian A (1810–69), apoth., Bombay & g. son of Jacob, band sgt., HM 84th Ft.
ARMSTRONG, John Wm. [IV, 384] b. c. 1–9–18	12–1–32 Calcutta	Karara, 1842–5; Gora, 1845–8, with ch. from 1847; ch. Hurilaong, 1848–52; Punjab, 1852–62; E. Calcutta Longl., 1862 till resd. 1909–64.	pr. son of Br. private soldier; m., Cawnpore, 9–12–39, Lavinia M.E. Hennessey, aged 17, pr. als. to J. B. N. H. (501).
ATKINSON, Geo. Wm. Elliott b. 11–10–43 d. Jan. 1904.	1–4–59 Calcutta	Kashmir, 1859–60; Punjab, 1860–2; E. Calcutta, 1862–3; Astr., 1864–5; Kumaun topo, 1866–70; PA. to STS., 1870–1; DDn DO., 1872–84, Simla PO. till 11–10–98 ret.	m., before 1871, Isabella Cleghorn, who d. DDn. 3–2–77; m., 2nd. before 1879 Constance Rose, who d., Mssri, 20–4–1916.
BELL, Francis Archibald John b. c., 26–4–52.	17–8–58 Mssri	Punjab 1859–63; CP., 1863–8; Kumaun topo., 1868; Kāthiāwār topo.; furl., 1865–6.	pr. bro. to Robt. Arthur [430].
BELLETTY, Nicholas Alex. b. c., 3–9–28. arrd. India aged c. 24	16–7–58	E. Coast, 1847–8; Hurilaong, 1848–53; Punjab, 1855–61; Compg. Off. 1861–2; Rewah topo., 1862, SGO. Calcutta, 1876 till ret. 1883, aged 55.	m., Agra, 6–5–60, Alice Mary dau. of Geo. Roberts, surg. of French Army.
BERRILL, Henry James b. c., 1–7–35 kd., Cawnpore, 1857.	17–11–51 Calcutta	N. Parasnāth, 1850–2; resd. to Rlwys., 1855.	pr. son of Robt., wr., SGO. 1834–8 [IV, 349]. or of Wm., Commt. Condr., Calcutta.
BERRILL, Thos. Alex. b. c., 1–6–30 kd., Cawnpore, 1857.	1–7–50 Calcutta	N. Parasnāth, 1850–2; Assam, 1852–6; resd., to Rlwys., 1856.	pr. bro. to Henry James [*sup*].
BEVERLEY, Henry b. c., 27–10–38 d., Shillong, 22–6–80; MI.	14–6–55	Punjab trgn., 1855–6; Assam, 1856–60; E. Frontier, 1861–9; in ch. parties in CP. and Burma '75 till death.	pr. bro. to Wm. Geo. [*inf*] and kin to indigo planters, Purnea.
BEVERLEY, Wm. Geo. b. c., 25–10–35 d., Poona, 22–9–82; ML	1–7–54 Calcutta	Hdqrs. GTS., 1854–6; Kashmir, 1856–63; E. Calcutta Longl., 1863–6; furl., 1866–8; Kumaun, 1868–70; ch. Assam & Burma 1874–8; Levelling. Deccan, 1880 till death.	m. before 1871, Leonora
BLEWITT, Francis Colwell b. c., 1–1–28. [359]	29–8–45	Wr., SGO., 1843–5; Gurwanl, 1845–7; NW. Him. 1847–50; NE. Longl., 1850–1; E. Coast, 1851–4; resd., Dec. 1854 to be missny; by 1860, Inspr. of PO. Patna.	pr. Kin to Francis Robb B., Customs, d., 18–8–81, aged 66; m., Calcutta, 24–6–52 Georgiana. dau. of Apothecary George.
BRAITHWAITE, Chas. Wm. b. c., 15–7–42 d., Mssri. 19–8–74; MI.	8–2–60 Mssri	Punjab 1860–2; Gwalior. topo, 1862–3; Kumaun topo., 1863–70; 3 y. leave from 1871; resd. 1873.	son of Wm.; m., DDn., 25–6–66, Adeline dau. of C. J. Davis; she m., 2nd., DDn., Warren Stirling, tea, planter.
BURT, Chas. Henry b. c. 1–8–33.	17–2–47 Mssri	NW. Him., 1847–50; Gt. Longl. & Induss 1850 till resd., 1855, to Sind Rlwys.; later to PWD.	son of Lt.-Col. Chas., Pomfret Burt, Ben. Inf. (1809–67), Hodson, I (262).
BURT, Jos. Thos. d., Mssri, 8–10–63, aged 24; MI.	12–9–60	Sutlej trgn., 1861–2; Vizagm. base, 1862–3.	pr. bro. of Chas. Henry [*sup.*].
CAMERON b. c., 1–3–29.	?	serving 1–5–50; resd. before 1860.	
CARTY, Chas. Jordan b. c., March 1830.	1–9–48 DDn.	Chendwar, 1848–50; NW. Him. & Punjab, 1850–8; Levelling 1858–62; E. Calcutta Longl., 1862–3; resd., 1863, ill-health.	
CLARKE, Lawrence Henry b. c., 4–6–34.	26–1–55 Simla	Punjab & Kashmir 1856–63; Sambalpur & CP. 1863–5; Levelling 1865–74; STS. Hdqrs., DDn., 1870; Soler Photo., 1872, ret., 1–7–86.	son of Daniel O'Brien C.; m. Mssrl. 7–12–61 Emma Matilda. Mills, wid. & dau. of Fredk. Shorte & sis. of Mrs. W. R. James [419].
CLARKSON, Richd. [IV, 384] b. 1817/8; bapt., Calcutta, 10–1–19	14–5–32 Calcutta	Maluncha, 2534–5; E. Coast, 1845–64; with frequent ch; ret., 17–8–64.	son of James Oram C. (1786–1848). Ben. Inf., Hodson, I (348) by Malay mother; m., Calcutta, 18–10–50, Mary Christians, dau. of J. R. Ross.
DA COSTA, Joseph [III, 386; III, 396; IV, 386] b. 1814/5.	7–8–37 Poona	Dmn. & Clerk, Bo. SGO., 1827 till disch. 1834; Bo. Trgn., 1837–61; ret. before 1864.	
D'SOUZA, Angelo b. 13–8–37.	19–2–56 Calcutta	Orissa topo., 1856–9; Assam trgn., 1859–62; Andamans, astr., 1862–3; Bo. topo., 1863; ch. Mersul trgn., 1875: 4 y. leave on mc., from 1877; CP. topo., 1884–9; Burma trgn. 1889–91; ret. aged 55, 13–8–92.	
DE, Ram Dayal [IV, 385]	9–4–40; Mssri.	Karara & Him. Longl., 1841–4; dism., 1844.	
DEVERIA, Jules	4–10–55 Darjeeling	Assam 1855–6; resd. Dec. 1856, to be Indigo planter, Bengal.	
DONNELLY, Alex. Watt b. 27–7–37 d. DDn., 23–10–73; MI. gives b. 22–8–38.	19–6–55 Murree	Punjab trgn. & Levelling, 1855–63; CP., 1863–5; Madras trgn., 1865–8; Levelling. 1865 till death, 1873.	son of Edw. & bro. to wife of Wm. Glynn; m., Mssrl. 1–9–60, Eliza, dau. of John Kirby.

[1] Date of indenture given here often later than that of posting.

Name, Birth, Death	Appointed	Employment	Domestic
DONNELLY, Edw. Theophilus	1-12-53 Calcutta	Punjab, 1854 till resd., 1859, to Rlwys.	pr. bro. to Alex. Watt [*sup.*]
DOUGLAS, John C. d., Srinagar, 17-10-57, from gun accident.	18-5-54 Mssri.	Punjab & Kashmir 1854 till death.	
DUNLOP, James Peyton b. *c.*, 1-22-32.	1-2-51	N. Parasnāth & Assam, 1851-2; Punjab, 1852-4; resd. 1-21-54, "constant ill-health"; to Punjab PWD.	m., before 1852, Mary Govan.
DUNLOP, John McGill b. *c.*, 1-7-28 d., Monghyr, 8-7-51.	24-7-55	Calcutta merdl., 1845-8; NE. Longl. 1849-50 Parasnāth, 1850 to death.	bro. to Jas. Peyton D. [*sup*].
DYER, Wm. Alfred b. Calcutta 23-7-36.	21-7-54 Mssri.	Punjab & Sind 1854-6; Assam, 1856-7; sick leave, 1857; resd. 1858 to brewery, Solon.	son of John, Ben. Pilot; bro. to Edw. & John [431]. m., 1st., 26-4-60, Allbd., Agnes E. C. dau. of J. H. Englebreyt; m., 2nd., Ghāzipur, 6-1-68 Adeline Jane, dau of P. P. Carter; m., 3rd., Rangoon, 2-3-82, Delphine Peters, wid., dau. of John Miller.
ELLISON, James d., Madras, 31-7-84; MI.	26-4-56 Calcutta	Orissa Topo., 1856-8; E. Coast trgn., 1858-61; Assam, 1861-2.	
FRASER, James [III, 386; IV, 356]. b. 1804/5 d., Poona, 15-12-63; MI.	1822	Bo. topo. & trgn., 1822-34; GTS., Bom. 1834 till resd., Aug. 1851.	m., before 1838, Isabella.
GLYNN, Wm. [IV, 384] b. April 1821.	9-9-40 Mssri	N. Conng. & Karara, 1844 till resd., 31-8-48; NWP. Customs, 1856; Asst. Comnr., Oudh, 1860, amateur photo. [331].	m., 1842, Caroline Amelia Donnelly, sis-in-law to Owen Mulheran.
HARRIS, Geo. Aug. b. 6-8-43 d., Shillong, 12-5-74.	26-1-61	appd. dmn sgo.; E. Calcutta longl., 1861-5; Kāthiāwār 1866-70; Assam trgn., 1871 till death.	
HAYCOCK, Alex. Theophilus b. *c.*, 1-11-31	16-7-47 Calcutta	Gt. Longl., 1847-9; DDn., 1849-51; E. Coast, 1851; resd. 1853, re-appd. 27-6-54.	son of Thos. & Mary Anne.
HENNESSEY, J. B. N.	14-4-44	Biographical Notes.	
HICKIE, Michael Chas. b. *c.*, 1-9-39 d., Mssri. 5-7-70.	21-12-55 Mssri.	Punjab trgn., 1855-63; CP., 1863-6; Bidar Longl., 1867-9; "health broken".	pr. son of Mich. Corbett, H., of HM. 16th Lancers, Meerut, and Collr. of Customs, Delhi, 1855; m., before June 1867.
JAMES, John Owen Nix b. 6-8-29 d. Mssri, 9-8-1900; MI.	29-7-45	Calcutta merdl., 1845-6; Chendwar, 1846-50; Punjab 1850-3; to topo., 1853 [431]; ret., 6-8-84.	son of Wm. Nix James [*inf.*].
JAMES, Wm. Nix [III, 371, 525; IV, 381] b. Jan., 1805 d., Chunār, 14-6-44.	30-9-21 Rev. Svy. 24-9-32 GTS.,	Budhon & Gt. Arc, 1832-43; ch. Gora, 1843 till death.	son of Lieut. Richd J. (1785-1813); Ben. Inf. Hodson, II (544).
JAMES, Wm. Richd. Nix [IV, 384] b. Dec. 1827 d. Murree, 3-9-75.	15-8-41	Calcutta merdl., 1844-5; E. Coast, 1845-50; Chendwar, 1850-1; NW. Him., 1851, till resd., 1854; appd. Dep. Collr., Jhānsi, svy. & settmt., 28-11-54.	son of Wm. Nix [*sup*]; m. Mssri., 5-7-52, Rosomond Helen, dau. of Fredk. Shorts & sis. to Mrs. L. H. Clarke (418); 2 sons at Stokes' Sch.
JOHNSON, Wm. Henry	1-9-48	Biographical Notes.	
KEELAN, Henry [IV, 384, 485]	18-5-32	Biographical Notes.	
KEELAN, Henry Elliott Thos. b. *c.*, 1-5-43 (?) d. nr. Tatta, Sind, 26-8-95	17-8-58 Mssri.	Kashmir & Punjab 1859-63; Sambalpur, 1863-4; Kumaun topo., 1864-5; Sambalpur, 1865-70; Pendulums, 1873-5; Levelling, 1882-4; ch. Indus Riverain, 1892 till death.	son of Henry [*sup*]; m. Amy, who d., 1887, aged 44.
KIRWAN, David [IV, 384] b. *c.*, 1-1-25	16-9-40 Mssri	Karara, 1840-5; E. Coast, 1845-6; Calcutta merdl., 1846-7; resd. 1847, to Indus & Punjab Canals; asst. Engr. Lahore, 1857, Lang (13-4 *et passim*); D.I.E. 1863.	son of Condr. David K.; m 1st, Benares, 26-9-48, Emma Eveline, dau. of Wm. Dalby; m., 2nd., Mssri, 9-11-60, dau. of Robt. MacMullan.
LANE, Chas. Richd. [IV, 384]	14-5-31	Biographical Notes.	
LAWLEE, Wm.	16-7-47 Calcutta	Sonakhoda base; resd., 1847.	
LAWRENCE, John Hickson b. *c.*, 1-9-28.	31-3-45	Karara, 1844-5; E. Coast, 1845-6; Malluncha, 1846, till resd. 1847; Punjab Rev. Svy., 1847-51 (442).	
LOGAN, Geo. [IV, 454-5]	11-3-31	Biographical Notes.	
LOW, Wm. from England	1-7-50 Calcutta	E. Coast 1850, till resd. 1854.	recdd. by F. W. Simms.
MASTERS, Wm.	25-4-55	DDn. 1855 till resd., 1856 for Opium Dept.; Sāran Dist. 1863.	son of Hdmr., La Martinière Sch., Calcutta, & uncle to Lt Col. John Masters (b. 1914), DSO.; auth.
MCGILL, John b. 22-10-30.	1-10-51	Bombay 1851-73; ch. of Bo. trgn. & topo., 1873-81; Calcutta DO., 1881-3; furl., 1883 to ret. Oct. 1885.	son of Condr. John McG. Nizām's army (1784-1838) bro. to G. A. McG.
MULHERAN, J. [IV, 384, 487]	19-4-34	Biographical Notes.	
MULHERAN, Owen [IV, 384, 487] b. 1817/8 d. before 1854.	8-1-36 Meerut	Gurwani & NW. Him., 1846-8; on sick list & light duty 1844, till resd. 9-12-48.	son of Owen, who arrd India *c.* Nov. 1832; bro. to James [*sup*]; m., Allbd., 29-9-45, Susannah, dau. of Edw. Donnelly & sis. to A. W. D. [418]; she m., 2nd, Richd. Rivers, widr., Surg. of Calcutta.
NEUVILLE, Chas. Joseph b. *c.*, 18-6-34	1-12-55 Calcutta	CE.'s office, Ft. Wm., 854-5; Kashmir 1858-62; E. Calcutta longl., 1862-3; Kumaun topo. 1864-6; E. Calcutta & Brahmaputra 1865-72; till leave, "unfit for outdoor work"; Tel. Longs., 1876-7; Levelling, 1877-9; ret. 1882.	son of Pierre; m., DDn. Amelia, dau. of Wm. Guthrie.
NICOLSON, J. O. [IV, 385, 488]	1-9-36	Biographical Notes.	
NIKLD, Chas. Bridg(e)man [IV, 400] b. *c.*, 1-2-21.	5-2-44 Calcutta	Rev. Svy., LP., 1838-52; Calcutta merdl. 1844-6; E. Coast 1846, till dism., 12-12-50; PWD., Arakan, 1854.	on svy. Damudur floods, 1852-3, *IO Cal.* (176).
OLLIVER, Chas. Adolphus b. 1825/6.	20-1-44	Rev. Svy. LP., 1841-2 WT., SGO. 1843-4; Chendwar., 1844-7; NW. Him. 1847-50 E. Coast, 1850-2; resd. *c.*, Feb. 1852.	yst. son of Joseph [III, 491]; half-bro. to Geo. Elisha Terry [*inf.*].

Name, Birth, Death	Appointed	Employment	Domestic
OLLIVER, Thos. [IV, 385] b. c., 7-5-18 d. Sukkur. 15-4-78 ; MI.	28-9-37 Calcutta	Gora., 1844-6 Sonakhoda base, 1847-8 ; resd., 1-9-48, to Punjab Flotilla, Indus R.	bro. to Chas. [*sup*] ; m. Allbd., 28-9-46, Caroline dau. of Robt. Cline.
PASCHOUD, Fredk. Smith b. c., 1-7-33 d. Masri, 24-9-54.	Dec. 1847	Chendwar, 1847, till resd. March 1848 ; readm., 20-11-49 ; Hurilaong, 1850-2 ; at DDn. 1885 till death.	m., 1847, Frances Ellen Matilda.
PENNY, Fredk.	1-1-55 Calcutta	E. Coast, 1855 till dism. Cuttack. 8-11-58.	
PEYTON, John [III, 494-5 ; IV, 469-1]	1-10-28	Biographical Notes.	
PIERCE, Richd. Wm. b. Sehore, 11-6-29.	28-11-47 Landour	NW. Him. 1847-8 ; Gt. Longl., 1848-51 ; resd., to Bhopal Agency ; English mstr. Sehore Sch. 1862.	Son of F. Wm. P. & his wife Ann Maria, dau. of Richd. Sydmore riding mstr. 7th Ben Cav. ; m. Sehore, 1853, Emma Eleanor, dau. of Thos. Barwell, wr.
RADHANATH SICKDHAR [IV, 461-2]	7-5-32	Biographical Notes.	
ROSSENRODE, John Wm. [IV, 385] b. c. 16-9-20.	13-12-38 Calcutta	Chendwar, 1844-9 ; Hurilaong, 1849-51 ; Bo. trgn. 1851 till resd. 10-10-52.	son of Wm. [III, 499 ; IV, 385, 490], bro. to Wm. Chas. [*inf*].
ROSSENRODE, Wm. Chas. [IV, 385] b. c., 1-12-21 (?) d. Shillong earthquake, 12-6-97 ; MI.	13-12-38 Calcutta	Maluncha, 1843-7 ; Gt. Longl., 1847-54 ; E. Coast, 1854-8 ; Assam, 1858-60 ; E. Frontier, 1860 ; in ch., 1865-71 ; ch. parties in CT. & Nizām's Terr. 1871 till ret. 1-11-1876.	bro. to John [*sup*] ; m., 1st. Eliza, who d., Cherra. 10-6-66, aged 25 ; MI.. ; m. 2nd., Lucy Agnes, who d., 24-7-85, Shillong ; MI.
RYALL, Fredk. Wm. b. c. 5-11-42. d., Masri, 2-10-75	1-4-59 Calcutta	E. Coast, 1860-6 ; E. Calcutta, 1866-9 ; leave, mc. 1869-70 ; Kumaun topo., 1870-1 ; Bo. trgn., 1871-3 ; "health broken, physical & mental", resd. with gratuity Rs. 2,100.	bro. to Edw. Chas. ; m., Poona. 12-7-78, Winfred Victoria Parkhill, wid., dau. of James Rendell.
RYALL, Geo. J. b. c., 26-11-39	1-1-56 Calcutta	Punjab 1856-61 ; resd., 1863 to Punjab Jud. uncov.	pr. bro. to Edw., and Fredk. [432, *sup*].
SANGER, Thos. [IV, 486]	1-5-27 Poona	Deccan topo., 1826-8 ; Bo. trgn., 1838-44 till ret., 1858.	a son appd. Bo. Trgn., 1588.
SCOTT, Gilbert James	15-11-56 DDn.	Kashmir, 1857 till dism., 1-10-60.	bro. to Robt. [359].
SHELVERTON Chas. b. c., 1-8-30	1-1-51	Pay Off. Ft. Wm., 1848-50 ; N. Him. 1851-2 ; Assam, 1852-6 ; E. Coast, 1856-7 ; Punjab, 1858, till resd., 1860 to Rlwys. ; 1863, PWD. Kohat & D.I.K.	son of Chas. and bro. to Geo. [*inf*] ; m., before May 1854.
SHELVERTON, Geo. Henry Walter b. 25-11-31 d. in camp, Godāvari Dist, 26-2-71 ; MI. Masri. & St. Thos. Ch. DDn.	16-7-47 Calcutta	Calcutta merdl., 1847-50 ; W. Him. topo., 1850-4 ; Punjab, 1854-6 ; Kashmir, 1856-9 ; Punjab, ch. Gurhagarh, 1859-63 ; CT. & Nizām's Terr. till death.	bro. to Chas. [*sup*] ; m., DDn., 26-11-57, Rebecca Gibson, dau. of Thos. Fraser.
SHUTER, Wm. Francis	1-8-59 Calcutta	Assam & NE. Frontier, 1859, till resd., 1863.	pr. kin to Richd. Yelpy S. (1815-43) asst. Surg., d. Gauhati, 11-1-43 MI.
SMITH, James Hawes	27-4-54 Bombay	Bombay 1853-5 ; Gt. Indus, 1855-6 ; Punjab, 1856-7 ; E. Coast, March 1858 (483) till resd. 15-10-58, to Rlwys.	
STEPHEN, J. J.	28-9-46	Chendwar. 8-2-47.	
TERRY, Geo. Elisha [IV, 385] b. c., 1-2-18	9-11-32 Calcutta	Chendwar, 1844-5 ; Maluncha, 1845-6 ; Gurwani, 1846-7 ; Hurilaong, 1847-9 ; Chendwar, 1849, till dism. April 1850 ; Hd. Clerk, Collr.'s office Saharanpur, 1855 ; El Ry. Agra, 1863.	pr. kin to wife of Jos. Olliver [III, 491] ; 1st., wife d., DDn., 13-4-42 ; 2nd., wife, Julie Ann, d., Masri 17-6-49, aged 19 y. 8 m.
TROTTER, Wm. Francis	1858	Gt. Indus & Sutlej series, 1858, till ret. 1861, Ens. HM. 84th Ft. 18-2-62 ; Lt. BSC. 6-8-64 ; Capt. 1874 ; AS. Police Assam from 1865.	
WEBB, Chas. Robt. b. c., 1-9-25	23-1-44	Maluncha, 1844, till resd., Darjeeling, 1-10-47.	
WILLIAMS, Henry Wyndham Campbell.	1-4-59	Punjab 1859 ; E. Calcutta longl. 1862 till disch., 1863, unfit for fd. duty.	son of nc. or warrant officer of Art., Peshāwar, 1863.
WOOD, Chas. b. 21-7-42 d., Sagaing, Burma, 22-1-96.	6-5-58	Levelling, 1860-2 ; Kashmir, 1862-4 ; Compg. off. DDn., 1865-88 ; ch. Levelling 1889-90 ; ch. Rev. Svy. party, Burma, 1890-6.	son of Henry ; m., Masri. 3-6-64, Selina Matilda, dau. of John Stotesbury.
WOOD, John b. c., 28-2-45 d. Poona c., May 1847.	12-11-6 DDn.	Astr. Party, 1863-5 ; Bo. Topo., 1872 till death.	pr. bro. to Chas. [*sup*].

CHAPTER XXVI

CIVIL ASSISTANTS: TOPO. SURVEYS

Madras & Hyderābād — Punjab & Himālaya — Burma — Successful Careers — Allowances — Nominal Rolls.

THE only topographical surveys in progress in 1844 were manned from the Madras establishment, and distributed in three parties :—

Under Halpin in Ganjam :—Robert Howard, Charles Summers, Chatelier, Snell, and King [168–9].

Under Morland in Hyderābād :—Chamarett, Long, Turnbull, Parlby, Ignatio, and Leigh [177].

Under Ouchterlony in the Nīlgiri Hills :—MacMahon, Meneaud, and Claudius [v, 179]. MacMahon, Chamarett, and Long had served since 1805 [II, 351].

Whilst triangulation was the business of the military officer in charge, the assistants were experienced planetablers and draughtsmen and, writes Waugh,

> the qualifications of sub-assistants attached to the Ganjam survey are limited to the art of field draftemanship or topographical delineation of ground, in which they are expert. ... All the surveyors...have been trained to the specific duty of filling up triangles with topographical detail, and they are incompetent, either by training or previous education, to undertake any operations beyond the range of duty in which they have been mechanically instructed[1].

The standard of accuracy and attention to detail, more especially in the hills, had fallen considerably since the days of Conner, Garling, and Ward, and both Waugh and Thuillier had much to criticise [170–1, 176, 291][2].

By the time the Hyderābād survey was suspended in 1850, Chamarett, Richard Long, Parlby, and Ignatio, had been replaced by R. H. Long, Richard's son, James Peyton, nephew of John of the G.T.S., and James McGill. Turnbull, Leigh, and Long were now transferred to Orissa [169 n.2], Peyton was sent to Du Vernet's party in the Himālaya [202], and McGill to the Great Longitudinal series under Strange. At the same time Summers, son of one of Mackenzie's earliest pupils, was sent up from Orissa to the Himālaya. He was over 40 years of age and described by Saxton as "a big hulking fellow without the spirit of a mosquito". After some useful work in the foothills, he returned to Orissa two years later [202].

On the close of the Nīlgiri survey in 1851 Meneaud was transferred to the Calcutta drawing office ; and Claudius to Orissa.

The Ganjam party struggled along under Howard for two seasons after Halpin's death. His assistants had no spirit to work and he himself, though "a most respectable character", had not the energy "to keep those wild scamps in order". They were all saturated with fever. There was at first but little improvement when Saxton took charge in 1850, and with the assistants from the Hyderābād party moved north into the hill tracts of Orissa. Chatelier died in 1852 and Turnbull the following season. Saxton, however, gradually got the work moving, and in 1854 was joined by a second military officer Depree, and more sub-assistants. In 1856 the party was split into two and new recruits drawn from Calcutta schools [171–2]. "I am well aware" writes Waugh,

> that young lads brought up in the Metropolis...do not take kindly at once to a survey life. The transition is immense and the hardships and exposure severely felt. Unless great care is taken to initiate them gradually, ... as well as to inspire them with a manly love for the enterprising character of the duties, they will surely imbibe a distaste for the profession. ...

[1] DDn. 543 (66, 70), SG. to PA., 6–11–51 & 13–11–52. [2] samples of 1-inch work, v. pls. 8 & 9.

Calcutta lads are capable of becoming manly surveyors, and an ornament to the profession. I recollect leaving Calcutta in 1832 with a large batch of newly joined sub-assistants of the trigonometrical survey dressed in their pumps and kid gloves. In 6 months they all became as hardy and worthy a set of enterprising young men as one would wish to see [III, 361 ; IV, 372].

The civil surveyors of the Ganjam party have all been born and bred in the southern presidency, and...a young Calcutta-educated lad...may not feel quite so much at home... amongst them, unless the officers and leading civil surveyors are aware of this[1].

The two parties were formed from 1st September 1856, each with 5 sub-assistants and 2 draughtsmen ; they expanded later to ten each.

No. 1, under Depree :—Summers, Robert and George Howard, Claudius, De Souza, David Atkinson, and Antrobus,

No. 2, under Dyer[2] :—Snell, J. G. King, Richardson, Ellison, and Vanderputt.

Snell died of "jungle fever" during 1857. The draughtsmen were employed on planetabling during the field season and promoted to sub-assistant as found fit[3]. One of these, a son of John King, died in 1859.

On return from furlough in 1857 Saxton brought out a young man, John Harper, from Newport in Shropshire, son of a local tradesman, who proved a great acquisition to the strength of the party. Harper was just 19 years of age, and had won an exhibition to Christ Church, Oxford, from Newport Grammer School, but preferred to take up the arduous and adventurous life of a surveyor in India. He continued with the party till after Saxton's retirement in 1873, and died at Ootacamund "of a combination of bronchitis, dysentery, and consumption of the lungs"[4].

The Hyderābād survey was resumed in October 1855, under James Mulheran [178]. Leigh was the only one of the old staff to rejoin, being released from Orissa in May 1856 ; whilst Andrew Chamarett whose father had died in 1848 [384, 424], joined at the same time from Robinson's party. During his first season Mulheran started triangulation with the help of George McGill, who had only joined in April 1855, and James Smith who joined six months later, both being locally recruited. Robert Daly who joined in 1857 died in camp in November 1862.

PUNJAB & HIMĀLAYA

When Du Vernet moved to the Punjab in 1847 he was to run a chain of principal triangles westward towards Peshāwar and at the same time make a geographical survey into the mountains [35, 200]. The sub-assistants brought up from the Gurwāni series, James Mulheran, Charles Olliver, and Blewitt, had no knowledge of topographical survey, nor indeed at that time had any of the Bengal assistants. New recruits had to be raised and trained ; but, though the Surveyor General was authorized to entertain six especially for these Punjab operations, he could not detach a sufficient number of sub-assistants until after the completion of the base of verification in the Purnea District [19–20]. In the meantime, Mr. Mackinnon of Masuri having promised to prepare some candidates for our department, you will...be able to select two well-qualified lads from amongst his pupils and train them up under your own eye[5] [IV, 166 n.5 ; V, 402].

During 1847–8, Du Vernet recruited John Dyer, Pierce, and Burt, the two latter being transferred to the Great Longitudinal series the following year [37–8]. Johnson, Carty, and Talbot were entertained at Dehra Dūn during 1848.

Henry Keelan, an experienced triangulator, was posted to the party in October 1848, and was detailed with Dyer to run a line of triangulation and planetabling from Mussoorie to Simla and the Upper Sutlej. Having no experience of planetabling, and anticipating difficulty during the winter months, he asked to be moved to other work [201] which brought a rebuke from the Surveyor General ;

Any surveyor whatever should be able to manage a planetable after a little practice. Slowness is pardonable in a beginner, but no excuse can be admitted for failure. This implement is

[1] DDn. 665 (151), SG. to DSG., 1–12–55. [2] Dyer took charge after Saxton's departure on leave [173, 427]. [3] DDn. 665 (115), SG. to DSG., 8–10–55 ; 578 (83), DO., 4–7–56 ; 684 (2–3) ; 727 (2), Depree to DSG., 13–9–56 ; 12–4–57 ; 1–10–57. [4] Saxton family papers, which include letters from Harper 1873–4. [5] DDn. 524 (31), SG. to Du Vernet, 12–6–47.

intended to facilitate the delineation of the features of the country, and you would find it a more difficult task to do the work assigned to you without the aid of the table[1].

Keelan was not, however, pressed to become a planetabler. He spent the next three years on minor triangulation and traversing till in 1852 he was transferred to the Rahun series [50–3, 203–4, 206].

Up to the end of season 1849–50, whilst Olliver assisted on the principal triangles, Keelan, Mulheran, and Blewitt ran secondary and minor triangulation through the lower hills and along the great rivers, to provide points for sketching and route survey by Summers and the youngsters. From 1850 half-inch survey was carried far into the mountains [200–2]. Triangulation was entrusted to Mulheran and Keelan, and during season 1850–1 no less than 11,845 square miles of planetabling were completed by Mulheran, Summers, James Peyton, George Shelverton, John Dyer, and Johnson. Work on the higher ranges was carried out between March and October, and in the lower hills during the cold weather [4–5, 202–6].

From the end of 1852, charge was entrusted to Mulheran who had done magnificent work in the formidable snows of Chamba, and under him Shelverton, Dyer, and Peyton worked eastward to cover the upper basins of the Jumna and Bhagīrathi, and the Siwalik Hills to Hardwār. During 1853, Peyton was left in the drawing office, whilst Mulheran from the south, and Shelverton and Dyer from the north, just failed to make connection across the Great Himālaya, which had to be left to Johnson's grand effort on the 19,000 feet Nela peak the following year [208].

The mountain survey was now completed from the Ganges to the Kashmir border and the Great Trigonometrical Survey had gained a small body of topographical surveyors. This was further expanded by the more deliberate work of Robinson's party in the Punjab, and Montgomerie's topographical section in Kashmir, whilst Mulheran was transferred to re-start the Hyderābād survey [178].

It was a strange team that Robinson, himself quite inexperienced, had collected for his "military survey" of Hazara [208–9];

The Resident at Lahore sent me two European assistants; the senior, ... Mr. W. Lloyd, was a young man of good education and talent from the Civil Engineer's College at Putney [England]. Had he remained with me...he would have been of great assistance, ... but... just as we were about to commence field work he received the offer of an appointment in Bengal on considerably higher emoluments and resigned. ...

My junior assistant, Mr. J. Ingram, was deficient in mathematical knowledge, and knew nothing of drawing; .... it was some time before he became useful. Latterly he gave me much assistance in computing and in surveying in the plains, but he was never able to master the difficulties of sketching hilly ground. On the conclusion of the survey he was presented with a commission in the 1st Bengal Fusiliers for his gallantry in Hazara [208 n.6][2].

Besides these two gentlemen Mr. L. was for a short time posted to the survey. He was uneducated and utterly unprincipled. He remained with me for four months, during which time he did no work whatever. ... [He was] finally ejected from the Punjab.

He later obtained the services of "a moonshee and two European n.c.o.'s of the Sappers and Miners", who were becoming quite useful when the war of 1848–9 put a stop to the survey, and by the time that work could be resumed

the moonshee had deserted to the enemy. Sergeant Denton had been drowned on service in the Indus, and Corporal Cartly had been made a prisoner by the Sikhs at Attock; ... [he being] the only survivor, was too ill, and had no wish to return to Hazara[3].

When Robinson came under the orders of the Surveyor General in 1850 he was given Talbot from the Himālaya party and two new recruits, Joseph James and Platts [210–1]; Waugh had

purposely limited his establishment to a small number. ... It was my intention to expand this party gradually to 8 or 10, ... but great difficulty has been experienced in maintaining the former small number. From the difficulty of recruiting, Captain Saxton's party is below its full strength, and among the surveyors who composed Major Du Vernet's party those who evinced a real talent for topography have been transferred to the Hyderabad survey, to Lieutenant Robinson, and to the Kashmir survey.

[1] DDn. 493 (157), SG. to Keelan, 20–12–48. [2] Ex. Engr. Pegu, 1856; m., Thayetmyo, 14–8–61, Mary Louisa Kinkaid; 1865, Punjab PWD. till struck off Nov. 1866. [3] DDn. 533 (4), Report, DGR., 1–12–55.

It is beyond my power to give a rapid development to topographical operations at present ... I could undertake in two years to train up a considerable body of surveyors, but at this moment it would not be easy to find many candidates of sufficient character and...education, on account of the great demand...of railways and...public works[1] [403–4, 407–8].

None of Robinson's first young men stayed long. Talbot went off to revenue surveys in 1852, and Joseph James who showed promise of becoming a first class surveyor left two years later for a well paid post in the civil service [414]. Platts had "passed a good examination in mathematics" at Roorkee College, but was no surveyor. He was "too fond of reading hard at night and of a sedentary life for a man with so weak a constitution", and was sick most of his first season. In 1853 he left without notice and eventually joined the Education Department;

Although a good mathematician and clever, [he] had no turn for sketching ground, and was therefore warned to join Captain Strange in Sind...for geodetical duties. ... Being however dissatisfied with the low rate of salary which he found inadequate for a family, ... [he] resigned and quitted the Department before his indenture expired[2].

In 1852 a valuable recruit was obtained in Andrew Chamarett, son of the old Madras surveyor of the Hyderābād survey [IV, 256–7, 385; V, 177], and in 1853 the party was immensely strengthened by the posting of John James and John Dyer, Robinson reporting two years later that

Mr. James' work is...very beautifully executed, and can hardly be improved upon. Mr. Dyer worked very hard and has improved very much indeed on his former season's work. The penmanship of his last table is really excellent, and all he requires to make him a first-rate draftsman is to manage his brush a little better, so as to give more effect in his shading[3] [320].

Waugh inspected the party in March 1854;

John James and John Dyer came over to camp today and showed me their planetables. J.J.'s work is ... simply *perfection*. I do not think anything superior could be done in England or any part of the world[4].

During 1856 Robinson lost the services of Chamarett, transferred to the Hyderābād survey, and Dyer, posted to charge of the second party in Orissa. At the end of the year the party comprised John James, Hörst, Robert Bell, Edward Ryall, and Neale. Neale got into trouble three years later by assaulting villagers, and was debarred from further employment in the Punjab. He accompanied the party to Central India and by 1865 was "a really good topographical surveyor".

From 1857 a number of Robinson's assistants joined the Kashmir survey every summer to strengthen Montgomerie's topographical section. The Pindi party was considered the training party *par excellence*, and Robinson reports in 1856;

The computations are chiefly...performed by 3rd class sub-assistants. Besides Mr. James I have only three sub-assistants. ... Our maps take more time than any of our other operations, and if I...allowed of Mr. James computing they would fall almost hopelessly into arrears, neither could I allow anyone else to take any part in finishing and shading, ... for...differences of style and finish would be introduced which would utterly ruin the good appearance of the maps. ...

Whenever I can, I do employ the young hands on the less important parts so as to gradually train them, but if they meddled with the finishing and shading, I could not expect Mr. James to continue to take the interest he does in our really beautiful maps [291].

Of the three remaining sub-assistants, Messrs. Hörst and Bell have received careful and efficient training under my own eyes for nearly two seasons and, being moreover very steady and industrious, do whatever is entrusted to them well, and are a credit to the department. To them I am obliged to give by far the largest share of the computations, but as they are so well up to their work and...I exert so active a superintendence over them I have no fear for the consequences. Mr. Neale, ... is as yet...inexperienced and an indifferent mathematician. Whenever I have time for computing he computes with me; ... I trust in due time to make him as efficient as his brother sub-assistants. ...

I have endeavoured...to thoroughly teach and train such sub-assistants as you have sent me from time to time, and I believe...the result has been good[5].

James was transferred to Calcutta in 1858, and was replaced by Joshua Baness who had to be taught planetabling from the start [343]. Field-work was completed in 1859, and Robinson writes in his final report;

[1] DDn. 665 (63), SG. to DSG., 21–6–55. [2] DDn. 649 (63), SG to Mil. Dept., 19–9–53. [3] ib. (499), Report 1854–5. [4] DDn. 93 (87), SG. to DOR. 2–3–54. [5] DDn 731 (3); 714 (27).

I have trained no less than 17 surveyors and yet at no time have I ever had more than 7 assistants present at once, and, that only latterly. Owing to the cost of teaching and consequent retardation of progress I estimate that the value of a surveyor's work increases season by season in the following ratio ; First year, 1—Second year, 4—Third year, 6—Fourth year, 7.

After the 4th year the quality of the work continues improving, though there is not much increase in quantity, but as he requires less superintendence there is a considerable gain in other parts of the superintendent's work. ... The party is now well organized and thoroughly efficient and experienced. ... All depends on keeping experienced hands[1].

In further comments on his sub-assistants Robinson notes that

the good topographers are almost universally deficient in mathematical attainments, and that the good mathematicians are rarely good topographers. To my mind manly energy, honesty, zeal, good constitution, good sense, and drawing abilities, combined with *sufficient* mathematics to work out ordinary computations, are the real desiderata for our topographers. Of my present staff, there is not one who could pass the prescribed test, and yet there is not one I would like to change for any other sub-assistant[2].

This view was fully accepted by Thuillier, whose interests lay chiefly with the revenue and topographical surveys, though he ruled officially that

it would be well for us to avoid entertaining for the Department candidates who are deficient in the knowledge and acquirements so essentially necessary to ensure a succession of good and able members of the profession, ... thus guarding against liability to inferior work and failures. ... The Departmental test as laid down in the enclosed paper must be maintained, and I cannot consent to receive any young man who does not comply with these requirements[3] [403].

From 1856 to 1859 most of the planetable survey of the Kashmir party was carried out during the summer months by young military officers and a few assistants borrowed from Robinson's party. A strong topographical section was mustered for 1860 and Montgomerie gave the new-comers ten days preliminary training in mountain survey ; "each new planetabler was attached to one of the old surveyors with a duplicate board", and they were only "allowed to work independently when 'they had satisfied the surveyor...of their proficiency' ". Bell and Low worked down the Indus from Skardo, Ryall in the basins of the Nubra and Shyok, whilst Todd and Bolst worked eastward through Ladākh. Bell returned to Robinson's party at the end of the season, but the other four continued with the Kashmir survey till field work was completed at the end of 1864, covering the desolate ice-bound regions of Rupshu, Zānskar, Hanle, and the Chang Chenmo. From 1860 the triangulators Johnson, Beverley, Clarke, Neuville, and Braithwaite contributed nobly to the topographical survey by the fixing of adequate control points [234–6].

BURMA

When the Pegu survey was started in 1853 a number of Burmese and Karen boys were engaged for instruction as traversers and surveyors, very few of whom proved of any worth [447]. A few European assistants were picked up in Burma, but none with any knowledge of triangulation or planetabling [198–9].

William Montgomerie had been making surveys of Moulmein for the Commissioner and was posted to the Pegu Survey in 1864 at the age of 43 on a salary of Rs. 400 p.m., and pensioned off on the close of the survey[4].

Barnett and Cooper had both served in the Ordnance Artificer Company before joining the Pegu Survey, which Barnett did in 1855 and Cooper in 1863. Both were useful surveyors and on the close of the survey were transferred to Saxton's party on the borders between the Central Provinces and Madras.

Alexander Hobday worked as assistant surveyor under the Commissioner of Tenasserim in 1848, and as surveyor in Martaban and Moulmein between 1854 and 1856 drawing salary Rs. 650 p.m. He was probably connected with Alfred Hobday & Co., auctioneers and wine merchants of Moulmein as early as 1892 [194].

[1] DDn. 714 (102), Report, DGR., 3–10–60. [2] DDn. 42 (108), DGR. to SG., 8–8–61. [3] DDn. 687 (65) SG. to DGR., 7–8–61. [4] *IO Cat.* (512), Sketch map, Shān States, 1856–7 [431 n. 1].

SUCCESSFUL CAREERS

The topographical assistants of the Madras uncovenanted establishment included none of good education, high professional qualifications, or capacity for organization and leadership, and the Madras system of appointing military officers of no professional experience did not bring out the best work from the assistants. Recruitment in the Madras parties was moreover very much a family affair.

When topographical surveys were started in upper India the matter was different. Recruitment was carried out under the direction of the Surveyor General or his Deputy. Candidates were given suitable tests and short periods of training at headquarter offices before being posted to field parties. There were disappointments of course, and many good men were tempted to other employment by more attractive prospects, but there were just as many who found the outdoor professional life gave full reward for the severe conditions [405]. Waugh urged his officers to

> appreciate and respect those who have adhered with fidelity to this honourable but poorly paid department. ... There is something in our noble profession and in the administration of the Department which, in spite of the moderate prospects, attaches real good men who feel they have the ability and the determination to succeed in it. By this we are taught to foster only men of real talent, and to give them opportunities for distinction as the...surest, way of attaching them to this hard-working and honourable service[1].

Whilst the majority of the topographical assistants became first-class planetablers and draughtsmen, it was but a small minority who combined the necessary character to make good as executive officers in charge of parties. The main reason for closing down the Hyderābād survey in 1850 had been the inability to spare an officer of the necessary experience and character to manage a topographical party working at such a great distance from headquarters, in a country where tact and discretion were of the greatest importance. It was not until the close of the Himālaya survey in 1854 that the Surveyor General could spare James Mulheran to take up this responsible task and to start afresh. His appointment dated from 1st January 1855 and carried salary of Rs. 600 a month [178].

Mulheran had more than 12 years experience on principal triangulation, starting with three years under Everest's immediate notice. He had just completed seven years strenuous work in the high Himālaya on both triangulation and planetabling, holding charge for the last two years, and winning the Surveyor General's complete confidence. "You have only to go on...doing your work and gettting business out of hand, and the Hyderabad survey cannot fail to succeed[2]".

> Mr. Mulheran is an experienced surveyor, ... distinguished for tact, judgement, and conciliatory disposition. His recent surveys in the Kangra District...elicited the repeated approbation of the Civil authorities, not only for the intrinsic merit of his professional performances, but on account of his honourable and just conduct...with the inhabitants of the country. I happened myself a few years back to traverse a portion of a district which had been under survey by Mr. Mulheran, and that gentleman's name lingered in the affectionate remembrance of the people[3].

In his final report before leaving India Waugh was equally warm in his praise, and noted particularly that "from his long training on the Trigonometrical Survey he has been able to carry out the triangulation on which the work is based in a style of accuracy not previously attained...by previous superintendents[4]". Ten years later, like many other devoted surveyors, Mulheran died in the course of a strenuous field season.

Waugh debates the selection for temporary charge of the second Orissa party whilst Saxton was on furlough [172, 429];

> With so much training and organization going on, the officiating officer must be peculiarly well qualified and experienced. ... Omitting those already at the head of parties, and all too junior or inexperienced, the following...would be the most fit: ...
>
> J. James, Esq.: Civil 2nd Assistant, Great Trigonometrical Survey, attached to the Topographical Survey, Jhelum and Rawalpindi.

[1] DDn. 600 (164), SG. to Strange, 1-12-55. [2] DDn. 588 (170), 7-12-54. [3] DDn. 656 (7), SG. to Resdt. Hdbd., 11-1-55. [4] DDn. 593 (361), Report 1859-60, 6-10-60.

G. Shelverton, Esq. : Senior Sub-Assistant, ... attached to the Jogi-Tila meridional series.
J. Dyer, Esq. : Senior Sub-Assistant, ... topographical survey, Jhelum and Rawalpindi. ...

Mr. John James is not perhaps adequate to the conditions of the case. He is Lieutenant Robinson's right-hand man ; the final maps of Jhelum and Rawalpindi are in his hands. It would be inconvenient to the public service to move him. He would gain little or nothing individually, and his interests are sufficiently well cared for by leaving him where he is.

Mr. Shelverton's health has not been good lately. He is Lieutenant Walker's right-hand man [52 n.4]. The Surveyor General has a high opinion of Mr. S.'s abilities as a triangulator and refined observer, also of his theoretical knowledge, skill as a computer, and intellectual powers, but he cannot be spared from his present post, and as he will be promoted if he gives satisfaction to Lieutenant Walker, Mr. S.'s interests are sufficiently cared for.

Not so Mr. John Dyer who occupies a tertiary place, and whose energy has been conspicuous. He can better be spared from Lieutenant Robinson's party, and his officiating appointment will give him a chance of distinction[1].

Robinson agreed with the Surveyor General's appreciation ; James was the only assistant at all capable of compiling the maps of the party, and moreover he sets such an excellent example to the younger members of the party that I look upon him as the main promoter of zeal for neatness, good drawing, great accuracy, and general good feeling, which distinguishes all the assistants of the party [409]. ...

Mr. John Dyer has been with me two years, and...has made very great progress as a topographical draughtsman. He is—after Mr. James—by far my best assistant, and his withdrawal from the party will be a great loss to it, the more especially that Mr. Chamarett also leaves at the conclusion of the season [178, 428].

Of Mr. Shelverton...I know but little. ... The style of his work in the Himalayas I do not admire. He is superior to Mr. Dyer as a mathematician ; equal as an observer, perhaps superior ; much inferior as a topographical draughtsman, and inferior in tact[2].

Dyer's appointment was duly sanctioned, but before he started he was censured for absence without leave. He was engaged to marry a sister of his brother officer, Robert Bell, whose guardian at Lahore was suddenly "ordered off post-haste to Nagpoor". There was no time to wait for official leave, and Dyer gallantly risked all—hastened to Lahore—and married the maiden[3]. Waugh later thanked Thuillier for helping Dyer on his passage through Calcutta ; and "for all your kindness to Dyer who is enchanted with your goodness. He is a man of your own choice, and I only claim credit for doing justice to your selection"[4].

Dyer did a good season's work, in the Sambalpur area, 1856–7, holding charge till Saxton's return [171–2]. He gave valuable assistance to the local political authorities during the difficult times of 1857, and his services were lent to them after Saxton's return. The Commissioner acknowledged his "very ready and correct execution of all duty assigned to him. He showed himself a fearless and efficient leader in several expeditions against the rebels in the Sambalpore District"[5].

Though the Surveyor General had obtained his substantive promotion "to the next uncovenanted grade of...four hundred rupees", Dyer preferred to accept an appointment in the junior civil service from February 1858[6]. In later years he settled as a barrister in Mussoorie.

John James, whose elder brothers left the Survey for the uncovenanted civil service, accompanied Logan's party to the Punjab in 1850, was transferred to Robinson's party in 1853, and proved an exceptionally fine planetabler and draughtsman [211, 414, 424]. After inspecting the party the following season the Surveyor General observed that planetabling required "considerable artistic talent" ;

Amongst the assistants...the senior, Mr. John James, stands pre-eminent for his great skill in delineating ground with scrupulous fidelity to nature. I have never seen a better hand at drawing ground. He is also excellent in every other part of his duty, and very zealous and fond of his work. ... I would...submit the name of Mr. John James...for promotion to the new grade of 1st Class Sub-Assistant, ... whereby his salary will be augmented from Rs. 173 to 220 per mensem. Mr. John James on the 5th July will have completed 9 years service[7].

[1] DDn. 577 (25), 19–12–55. [2] DDn. 731 (4)/ 6–1–56. [3] DDn. 731 (141), DGR. to SG., 24–2–56 ; SG.'s censure, DDn. 588 (201), 3–3–56. [4] Dyer was recruited in Calcutta, son of a Hooghly pilot [431]. [5] DDn. 686 (4), Comnr. Cuttack to Saxton, 3–4–58. [6] DDn. 14 (25), Mil. Dept. 1641 of, 29–1–58 ; remained Extra Asst. Comnr., Sambalpur, till 28–2–62. [7] DDn. 547 (237), SG. to Mil. Dept., 15–6–54.

In 1858 he was moved down to succeed John Graham at Calcutta where he continued in charge of mapping for the next twenty years [353].

James Peyton, nephew of Everest's old surveyor John, joined the Hyderābād survey in 1847 and was transferred to Du Vernet's Himālaya party in 1850 where he established himself as an exceptional draughtsman and excellent planetabler. After taking a large share in the map-drawing he resigned in 1855 to study painting in Italy. Returning in 1860, he was re-admitted, and employed in the drawing office at Dehra Dūn. From 1863 he was served with various topographical parties without ever rising to hold charge. He wrote up the account of the Himālaya survey of 1847–54 that is published in *Synoptical Volume* No. VII [208]. He wrote for the papers and painted portraits. From 1880 he was employed at the Calcutta drawing office where he effected "considerable improvement ...in the hill-shading by brush-work". He retired in July 1886 at the age of 55[1].

Andrew Chamarett the elder had joined the Tanjore survey in 1807 [II, 146 n.4, 351], and had for long been a tower of strength in the Hyderābād party [384]; Major Morland was frequently absent on sick leave, during which...his place was ably supplied by Mr. Chamarett. ... Major Brown had no previous training as a surveyor [177–8, 384]. ... My chief reliance therefore could only be placed on the old sub-assistants, and especially on Mr. A. Chamarett who was fit to conduct the survey himself if not interfered with. Unfortunately this worthy fell ill shortly after Major Brown took charge, and was obliged on the 15th November [1848] to proceed to Bombay on sick certificate. He died on the journey at Poona on the 18th December after a long and faithful service of 44 years [430][2].

Andrew Chamarett the younger was entertained in 1852 and learned his survey in Robinson's party, being transferred to his father's old party when the Hyderābād survey was reformed in 1855. He remained with that party after its move into the Central Provinces and till his own transfer to the Calcutta drawing office. He retired as as Chief Draughtsman in 1884.

Robert Bell joined Robinson's party in 1854 and moved with it to Gwalior in 1860. During the summer months of 1857 and 1860 he worked with the Kashmir party. In 1862 he was transferred to the Rewah survey where he died in the field, May 1867.

Henry Hörst also joined Robinson's party in 1854 and accompanied it to Gwalior in 1860. After more than ten years with the Rājputāna survey from 1863, he held charge successively of topographical surveys in Khāndesh and Burma, retiring at the age of 55 in 1889.

Edward Ryall was posted to the Rahun series, G.T.S., in 1855, but was transferred to Robinson's party the following year. He worked for several summers in Kashmir, mostly in the Karakoram and eastern Ladākh [231, 234–7]. He was then attached for a few months to trigonometrical units before taking sick leave to England. From May 1867 he joined the topographical survey of Kumaun and Garhwāl, holding charge 1875–8 and making notable surveys in the high Himālaya[3]. He later held charge of surveys round Darjeeling and then spent the last few years of his service on triangulation along the Madras coast before retiring in 1890.

Of the younger surveyors David Atkinson and George McGill had long and worthy service in topographical surveys.

We may here note the heavy roll of untimely deaths amongst the topographical surveyors, Mulheran ; Robert Bell ; Andrew Chamarett senior ; Joseph Chatelier ; Black ; Thomas Claudius ; Robert Daly ; Harper ; W. King ; James McGill ; Richardson ; Charles Snell ; William Turnbull ; all but two occurring from the Madras or Hyderābād establishments.

Up till 1861 all the Bengal appointments had been made to the Great Trigonometrical Survey. When, however, the office of Superintendent of Trigonometrical Surveys was separated from that of Surveyor General and Henry Thuillier assumed the role of Deputy Surveyor General Topographical Surveys, a separate Topographical Branch was set up both for military officers and uncovenanted assistants,

[1] *GR., 1879–80* (51 n.). [2] DDn. 542 (37), SG. to Mil. Dept., 28–8–50. [3] Mason (78, 82, 137–8).

just as there had long been for revenue surveys. Postings were left to individual choice, but there was later some cavil at the comparative rates of promotion in the two branches.

ALLOWANCES

The regular allowances authorized in 1832 for sub-assistants of the Great Trigonometrical Survey had been made applicable to those of the Madras survey establishment the following year [IV, 371 n.4]. The question of temporary charge had been raised in 1840 by Chamarett of the Hyderābād party, who was allowed Rs. 350 a month, "the salary of the Assistant Surveyor General in charge" [386], in addition to his ordinary pay and allowances. When he raised the claim again the Surveyor General pointed out that the Madras Pay Code prescribed an acting allowance of Rs. 170 p.m., and the Bengal Revenue Survey Regulations Rs. 138 p.m., and Government now authorized, "whenever the charge of a Survey may devolve on the senior sub-assistant of a party, the grant of a 'charge allowance'...of Rupees one hundred (100) per mensem[1]".

The Surveyor General obtained more generous terms for Dyer on his appointment to charge during Saxton's absence on furlough [426–7]. This was not a case of the senior assistant of the party acting temporarily in charge ;

> The salary attaching to the situation of Assistant in the Topographical Survey is Co.'s rupees 250, which Mr. Dyer will be entitled to draw. In addition to this he will also receive a deputation allowance equivalent to half of Captain Saxtons's allowance of Co.'s rupees 450 during the period he officiates for that officer. ... The above arrangements are...for the benefit of the public service, and not for Mr. Dyer's personal advantage, to whose immediate interests the transfer would be otherwise opposed, on account of the great expense he will be subjected to in sacrificing the present equipment and re-equipping again at a distance of nearly 2,000 miles. ... His case should be dealt with in a liberal spirit. ...
>
> I...recommend that Mr. Dyer, who is a married man [427], be permitted to submit a bill for his own bonafide travelling expenses from Rawalpindee via my headquarters and Calcutta to Cuttack, also that his appointment with respect to his salary as Assistant on the Ganjam Survey—and deputation allowance equivalent to half Captain Saxton's allowance—be allowed to reckon from the date on which he leaves the party to which he is at present attached. ...
>
> To his ability to meet these expenses in a manner becoming his position, Mr. Dyer's efficiency will partly depend, as well as the ascendancy of his example as head of a party, and the preservation of his present vigorous health in the very deleterious climate in which the survey operations will be carried[2].

Under Madras regulations each sub-assistant was allowed the pay for 3 lascars which he drew right through the year on the understanding that no further charge was made for lascars or *khalāsis* [III, 395–6]. This arrangement ceased when the Madras parties were brought on to the Bengal establishment in 1859 [399].

"Mountain [or Hill] allowance" was authorized for the N.W. Himālaya series in 1847, and extended with modifications to other parties, both geodetic and topographical. "Travelling allowance" was not authorized till 1865 [375–6, 399][3].

Dyer describes the heavy expense to which both he and his brother were put by accidents to their ponies. They were planetabling in the hills beyond Simla ;

> Owing to our inability to maintain dandies on taking the field in October last—no allowance on that account having been then extended to...the Department—...my brother and self had no alternative but to take our horses with us. For some time this...answered admirably and enable us to progress rapidly with our work, but in January the winter set in with great severity, and the road became quite impracticable. ... The only means of extricating them was to send our horses by a lower road, ... but unfortunately [led to] the destruction of both animals. My brother's mare, for which but a few months previous he paid 175 rupees, went over a precipice and was dashed to pieces. My own pony, after floundering desperately in snow up to his girths, slipped down about 50 feet over a rugged steep, and broke his back. ...

[1] DDn. 451 (113), BMO., 24–5–44 ; confirmed by CD. to B., 7–3–45 (29–30). [2] DDn. 643 (47), SG. to Mil. Dept., 15–2–56 ; sanctioned, DDn. 577 (27), 24–3–56. [3] DDn. 493 (350), SG. to DGB., 28–9–50.

In a precisely similar case an application for compensation preferred by the late Superintendent of the Simlah and Thibet road was duly sanctioned by Government[1].

It was after this catastrophe that Du Vernet appealed for an extra allowance for work in the higher mountains where it was impossible to take ponies [371];

My assistants...require to pass direct from one point to another regardless of roads and paths, and, as their horses and ponies...are not only useless but an incumbrance, they are obliged to leave them at some point near the plains or send them back to quarters, and traverse the country on foot. But walking in a mountainous country where roads are not available is exceedingly laborious and a surveyor, after plunging into a valley 5,000 feet deep and gaining some point on the opposited side equally elevated, ... is exhausted and in no condition to perform his duty. ... Much valuable time is lost and, from my own experience, by no means can he keep fresh and in a state to observe and sketch, ... unless transported from point to point in a pilgrim's jampan, a sort of basket carried on poles by eight men. ...

My assistants should be effectually equipped. ... They have no allowance to meet the additional expense of jampany hire, whilst they...keep up their usual means of travelling. .... I...suggest...that I...furnish each...with eight hill men for a pilgrim's jampan, charging the same in my contingent bill. The additional expense...will be rather more than 40 rupees monthly during field operations, as hillmen will not engage for mountain service under Rs. 5 per mensem, stipulating for Rs. 6...in the snows above Rampoor and Chini[2] [479].

Dandy allowance at Rs. 20 a month was duly sanctioned for each sub-assistant whilst working in the higher mountains, over and above the mountain allowance previously sanctioned [375][3].

NOMINAL ROLL: 1844–61

Name, Birth, Death	Appointed[4]	Employment	Domestic
ADAMS, Fredk. b. 25–4–36.	3–11–56	Orissa, dmn., 1856–60; SAS., 1–10–60; No. 3 topo., 1861–74; Calcutta DO. 1874 till ret. aged 55, 25–4–91.	possibly kin to Lieut. Adams with Hermann Schlagintweit [145].
ANTROBUS, Deodatus b. c. 5–4–25.	1–9–56 Cuttack	Orissa, 1856–61; No. 3 topo., 1861–4, with leave to England twice; Rewah, 1864 till resd., 1–11–65.	
ATKINSON, David b. 8–5–37.	4–8–56 Cuttack	Orissa, 1856–8; E. Coast trgn., 1858–9; Orissa topo., 1859–61; No. 3 topo., from 1864; Khandeah, 1874–5; Bhopál, 1876; Astr. Party, 1881–5; with Dir. Statistics, 1885–6; svy. Calcutta city till ret. aged 55, 8–5–92.	pr. bro. to G.W.M. & H.M. Atkinson [418, *inf*] and also to Edm. Stroud Paton, appd. topo. SAS. 13–6–61.
ATKINSON, Henry McArthur b., Australia, c., June 1842 arrd. India, 1846.	1–12–58 Calcutta	Orissa & Chota Nágpur, 1858–63; Calcutta DO., 1863–4; Khási Hills, 1864 till resd., 5–8–67, to become Asst. Engr.	1870, Masri., son b. to his wife Eliza.
BANESS, Alex. Fredk.	1–11–56 DDn.	Kashmir topo. 1857; Pindi, Jan. 1858; pr. resd. 1858; Customs Dept. Benares, 1862.	pr. son or kin to A. B. merch., Delhi, who d., 1842/3.
BANESS, Joshua Fredk. b. c. 1–7–30. d., Simla, 7–6–84.	5–9–56 DDn.	with Bd. Admin. Lahore, 1849–50; Asst. Bari Doáb canal, 1851–4; DDn. DO., 1856–60; attd. Pindi topo., 1858 till appd. SAS., 1–1–61; Gwalior, 1861–3; Rájputána, 1863; Calcutta DO. from 1869 CD. 1876; Asst. to DG. Statistics, 1882 till death.	pr. bro. to Alex. [*sup*]; m. Maria, before 1857. Auth. *Geographicus Indicus*, pub. Calcutta, 1881; FRGS.
BARNETT, W. S. b. c. 1–8–22.	17–3–55 Burma	Ordnance Dept., 1846–55; Pegu Svy., 1855–68; No. 3 topo. 1868 till ret. on pension, July 1870.	
BELL, Robt. Arthur b. c. 19–11–34. d., Malbar. CF., 4–5–67.	15–9–54 Masri.	Pindi & Kashmir topo., 1854–61; Gwalior, 1861–2; Rewah, 1862 to death.	son of Richd. Nelson B.; m., Masri., 15–9–62, Lucy Ellen, dau. of John Taylor.
BLACK, Alex. d., Cuttack, 17–5–59.	1–12–58 Calcutta	from Calcutta DO. to Orissa topo. till death.	
BOLST, Herbert James b. c. 2–3–57. arrd. India 1837/8; d., Masri., 7–7–79, MI.	26–7–52	dmn. SGO., 1852–60; Kashmir, 1860–1; Gwalior, from 1861; SAS. topo. 1–1–62; 2 y. furl to Eur. 3–11–73.	pr. bro to Wm. C. B. [359] and Geo. Chapman [439]; m., 1st., before, 1865, Helen Kate; 2nd., Emily Caroline, who d. Landour, 16–1–71, aged 31.
CHAMARETT, Andrew, senr. [II 351; III, 385; IV, 385] b., Jan. 1793. d., Poona, 18–12–48.	19–3–05 Madras	Madras svys., 1807–20: Hdbd., 1820 till death.	m., Scdbd., 8–10–20, Katherine Johannes; father of Peter, b., 1826, Nizám's med. est., and of Andrew (*inf*).
CHAMARETT, Andrew, junr. b. c. 20–11–32.	2–6–52 Cuttack	Pindi topo., 1852–6; Hdbd. & Bdlkd., 1856–70; Calcutta DO., 1871 till ret. as CD., 1–6–84.	son of Andrew, senr. (*sup*); pr. father of A. C., engraver, SGO., 1884.
CHATELIER, Joseph [IV, 385] d., Orissa, 28–11–52.	1–7–30 Madras	Madras topo., 1833–43; Ganjam, 1844–50; Orissa, 1850 till death.	
CHEW, Roger Wm. b. c. 23–7–39.	15–9–56 Calcutta	Orissa, 1857–61; No. 3 topo., 1861–72; Khándeah, 1872–5; Mysore, 1876.	son of Roger; m., Cuttack, 1–8–59, Phoebe Emily, dau. of Geo. Rayner.

[1] DDn. 606 (109), John Dyer to SG., 20–6–51. [2] ib. (104), 16–1–51. [3] DDn. 541 (292), BMC., 21–2–51; DO., 8–3–51. [4] Date of idenure given here often later than that of joining.

Name, Birth, Death	Appointed	Employment	Domestic
CLAUDIUS, Thos. [IV, 385] b. *c.* April 1816. d., Berhampur, Ganjam, 7–6–63.	1–7–80 Madras	Madras topo., 1833–43; Nilgiri Hills, 1844–54; Orissa & Ganjam, 1854 till death.	m., 1st., Jane Elizabeth, who d., Kotagiri, 16–6–48; 2nd., Ootcmd., 23–2–52, Charlotte Amelia, dau. of Geo. Haldwell; father of T. H. M., appd. No. 3 topo. 1863.
COOPER, A.	9–11–56	Ordance Dept., Burma 1854–63; Pegu Svy., 1863–7; No. 3 topo. 1867–75; Khāndesh 1876 till 1879.	Leave on ½ pay from 6–10–79.
DALY, Robt. d. in fd., Berār, 25–11–62.	1–8–57	Hdbd. Topo., 1857 till death.	pr. son of Whitelaw [IV, 385] & bro. to J. B. Daly *who* resd. as "native survr.", Hdbd. Svy., 8–9–58.
DYER, Edward Abraham b. Calcutta, 7–7–31. ed. England; arrd. India, March 1849 d., Simla, 23–4–1902.	30–5–49 Calcutta	NW. Him. & Pindi topo., 1849 till resd. 1851; studied brewing in England, and founded brewery, Murree, *c.* 1858; Solon, *c.* 1866.	son of John (b. 1799), Hooghly Pilot, 1816–48; bro. to John (*inf*) & Wm. Alfred [419]; m., Barnstaple, England, *c.*, 1856, Mary Passmore; father of Gen. R. E. H. Dyer (biog. by Ian Colvin, 1929).
DYER, John b. *c.* 1–8–29. arrd. India, 1847. —	16–7–47 Calcutta	NW. Him. topo., 1847–53; Punjab Topo., 1853–6; ch. Orissa Topo. No. 2, 1856–7; uncov. civ. service, Sambalpur, Feb. 1858 to 28–2–62; later barr. Mssri.	bro. to Edw. (*sup*); m., Lahore, 26–12–55, Caroline Colley. Bell sis. of Robt. Arthur [430]; 2nd., Mssri. 24–11–68 Grace, dau. of Thos. Conlan; she d., Mssri. 11–22–1900.
FARRELL, Robt. Dennis b. *c.* Feb. 1843.	1–10–60	Hdbd. topo., 1860–6; Gwallor, 1870–5; Mysore, 1876–7; in service, 1881.	
HARPER, John b. Newport, Salop, *c.* 15–4–38. arrd. India, Aug. 1857; d., Ootacamund, 23–6–75.	8–8–57	No. 3 topo., 1857 till death: mc. to England, 1868–9; svy., Jeypore. Vzgptm., 1869–73.	son of Newport tradesman; brought to India by G. H. Saxton [422].
HÖRST, Henry b. England, 5–5–34. arrd. India, 1854 d., Cuddalore, MI. und.	1–9–54 Mssri.	Librn. & Acct. Roorkee Coll., 1853–4; Pindi topo., 1854–61; Gwallor, 1861–3; Rājputāna, 1863–74; ch. Khāndesh, 1874–9; furl., 1879–82; ch. Burma topo., 1882 till ret. aged 55, 5–5–89.	son of Geo. Phillip; m., Murree, 8–5–56, Alice Frances Copping, wid., dau. of Wm. Powell; portrait with ASG.
HOWARD, Geo. Robt.	11–7–53 Cuttack	Orissa, 1853–8; E. Coast GTS., 1859 till resd., 18–6–62.	bro. to Robt. (*inf.*)
HOWARD, Robt. [III, 385; IV, 385] d. before, Nov. 1862.	1827 Madras	Madras topo., 1827–43; Ganjam & Orissa, 1843, till ret. on pension 1861?	bro. to Geo. (*sup*); wife d., Berhampur, Ganjam, Jan. 1849.
IGNATIO, Colin Francis [III, 385; IV, 386]	9–5–27 Madras	Hdbd. topo. 1830 till dism. 1–9–47.	m. Maria before 1839.
JAMES, John Owen Nix [359]. b. Calcutta, 6–8–29 d., Mssri., 9–8–1900; MI.	29–7–45 Calcutta	GTS. units, 1845–53 [419]; Pindi topo., 1853–8; ch. Calcutta DO., from 1858; Survr. & CD., Feb. 1861; ASG., maps, from 1870; furl., 1878–9; ch. 8 Party, Rev. Br., Aligarh, 1883, till ret., 7–8–84.	son of Wm. Nix [III, 371; IV, 374]; bro. to Richd. Nix [419] & Joseph [*inf*]; m. Peshāwar, 5–2–56, Matilda dau. of H. S. Bristow.
JAMES, Joseph Arthur Nix b. *c.* May 1827. d. *before* 1860.	1–9–48 DDn.	Pindi topo., 1850, till resd., 1854, for appt. to uncov. civ. jud. service, Bundelkhand.	bro. to John (*sup*) and Wm. Richd. [419].
KING, John Geo. [IV, 286] b., May 1816.	9–3–35 Madras	Madras topo., 1837–43; Ganjam & Orissa, 1844, till ret. 1862.	father of W. K. (*inf*).
KING, W. d. Orissa, 16–12–59.	1–7–57	dmn. Orissa Topo., 1857 till death.	son of John Geo. (*sup*).
LEIGH, James [III, 385; IV, 336, as John]. d., Calcutta, 7–10–55; MI.	14–4–27 Madras	Hdbd. topo., 1830–51; Orissa, 1855–6; Hdbd., 1856 till ret. 19–9–63.	son of James; wife Mary & 3 children alive 1863.
LONG, Richd. [II, 351; III, 385; IV, 386] b., 27–7–1793 d. Scdbd., 7–10–55; MI.	27–4–05 Madras	Madras topo., 1810–21; Hdbd. topo., 1821 till pension, 1–9–47.	m., Trichur, 13–12–20, Ann Watts; father of R. H. (*inf*).
LONG, R. H.	1–7–45 Hdbd.	Hdbd. topo., 1845–50; Orissa topo., 1851, till resd., 1855, "after continuous fever".	son of Richd. (*sup*).
LOW, James b. *c.* 1–3–40.	1–10–57 Calcutta	Assam trgn., 1857–9; Kashmir topo., 1860–4; Khāsi Hills, 1864–6; 12 mo. leave mc. to Europe, 1857–8 & 1866–7; Kumaun, 1868–70; 18 mo. leave from Burma topo., 1875, till furl. 1877.	31–7–68, his dau. Maria m., DDn., Thos. Kinney.
LOWRY, John Wm.	27–10–54 Calcutta	Orissa topo., 1854–5.	
MCGILL, Geo. A. b. England, *c.*, 24–4–38 arrd. India, 1858, d., Calcutta, 4–1–92.	8–4–55 Ellichpur	Hdbd. topo., 1855–62; Chota Nāgpur, 1862–73; Rājputāna, 1876–8; Calcutta DO., 1882; CD., 24–6–84 till death.	son of John, Dep. Commy., Nizām's est.,; bro. to James (*inf*) & John [419]; m., before 1872, Arabella Agnes.
MCGILL, James Hamilton b. 1827/8 d., Tret, nr. Murree, 1–12–53.	15–2–49 Aurangābād	Hdbd. topo., 1849–50; Gt. Longl. trgn., 1851–2; Pindi topo. 1853 till death.	bro. to Geo. (*sup*), and John [419].
MACMAHON, Chas. Robt. [II, 351; III, 385; IV, 386] b. *c.* Oct. 1791.	19–3–05 Madras	Madras topo., 1805–44; Nilgiri Hills, 1844–54; pension from, 3–10–55.	m., Maria, dau. of Maj. S. A. Rebe, Mad. Inf.; she d., Ootcmd, aged 41; MI.
MACVITTIE, Edw. Francis b. *c.* 13–8–42.	1–8–57 Calcutta	Calcutta DO., 1856–7; Orissa, 1857 till resd., Nov. 1861.	
MAY, John Albert b. 15–5–41. d., DDn., 26–6–86; MI.	1–10–60 Calcutta	Orissa & No. 3 topo., 1860 to May 1877; Calcutta DO., 1877–84; Khāndesh topo., 1884–5; DDn. DO. 1885, till death.	m., Agnes Blanche, who d., Mssri, 17–5–1920, aged 70; MI.
MENRAUD, Augustus [III, 386; IV, 386, V, 360] b. July 1807.	17–8–23 Madras	Madras topo., 1823–44; Nilgiri Hills, 1849–53; Calcutta DO., 1854–5.	son of Auguste, who arrd. Madras from France 1789; m. Matilda before 1832.
MONTGOMERIE, Wm.[1] b. *c.* Dec. 1821 arrd. India, 1821.	1–12–64 Rangoon	asst. survr. under Comnr. Moulmein from April 1853; tr. to Pegu Svy., Dec. 1864; disch. at Madras, with pension @ Rs. 133/4 p.m., 30–6–67.	wounded by tiger, Arakan Hills, 13–4–65.

[1] *IO Cal.* (466); map shewing Wm. Montgomerie's project for telegraph line India to China; identity doubtful.

Name, Birth, Death	Appointed	Employment	Domestic
NEALE, Clarence. H. T. b., Yorkshire, 1839/40. arrd. India, 18–4–55.	21–4–55 Calcutta	Pindi & Kashmir topo., 1855–9; Gwalior, 1860–2; Rewah, 1862–6; Hdbd. Topo., Berār, 1866–70; two y. leave to Europe from Aug. 1870.	pr. son of Rev. Wm. Henry N. master of Beverley Gr. Sch., Yorks; m., pr. Agra, c. 1860, son b., 8–3–61.
PARLBY, Chas. Henry [III, 386; IV, 386] d., Hdbd., 6–1–73, aged 62; MI.	9–8–27 Madras	Madras topo., 1830–43; Ganjam, 1844–6, pr. resd. 1846.	m., Sodbd., 8–7–36, Sarah Elizabeth O'Leary.
PEW, John Geo. b. c. Dec. 1839.	1–12–58	Orissa topo., 1858, till resd. Nov. 1861.	from St. Paul's Sch., Calcutta.
PEYTON, James b. 1–7–31.	1–8–47	Hdbd. topo., 1847–51; NW. Him. topo., 1851, till resd., 1855; reappd., 1860; DDn. DO., 1860–3; Kumaun, 1863–7; Kāthiāwār topo., 1874–6; Calcutta DO., 1876–84; Darjeeling topo., 1883 till ret. aged 55, 1–7–86.	son of James (1800–84), of Nizām's Army; nephew of John [IV, 460–1; V, 428]; his wife Kathleen d., Poona, 12–10–89, aged 38. MI.
PLATTS, John Thompson	25–9–50 DDn.	from Roorkee Coll. to Pindi topo., 1850 till resd. May 1853 for Education Dept.; 1862, Hdmr. Benares Coll.	Son of Robt.; m., Landour, 20–9–51, Elizabeth, dau. of Rudolph Perkins.
RICHARDSON, Richd. b. c. 1830 d., Cuttack, 29–4–57.	10–11–54 Calcutta	11–8–54 Dmn. SOO.; to Orissa 1854 till death.	
RYALL, Edw. Chas. b. c. 16–1–38.	25–4–55 GTS.	Rahun trgn. 1855–6; Pindi & Kashmir topo., 1856–64; E. Calcutta & Frontier trgn., 1864–6; Kumaun & DDn. topo., 1867–75; In ch., 1875–8; ch. Darjeeling topo., 1881–4; E. Coast trgn., Madras, 1885 till ret., 26–9–90.	son of Chas. Harrison, R.; bro. to Frdk. Wm. [420]; m. DDn., 26–1–64, Eliza Margt. dau. of J. B. Luckstedt.
SMITH, James Benjamin b. c. 1–4–37.	21–9–55 Poona	Hdbd. topo. 1855 till resd., 20–9–65; re-appd., Nov., rejoining May 1866; left for PWD., Accts. Bombay.	parents living in Bombay 1865–6.
SNELL, Chas. Junr. [IV, 336] d., in Orissa, 5–3–57.	1–12–32 Madras	Madras topo., 1833–42; Ganjam & Orissa, 1844 till death.	nat. son of Chas. Snell, Mad. Inf. [III, 504].
SUMMERS, Chas. Augustus [III, 386; IV, 886] b. c. Feb. 1808. d., 1860/2.	1–10–21 Madras	Madras topo., 1821–43; Ganjam & Orissa, 1844–50; NW. Him. topo., 1850–3; Orissa, 1853 till pensioned, 1860/1.	son of James [II, 352; III, 386]; wife, Caroline Rubina, d., Poona, 2–7–56, aged 28.
TALBOT, Henry Blaquière b. c. 1–11–30.	1–9–48 DDn.	NW. Him. topo., 1848–50; Pindi topo., 1850 till absent from 6–7–52; to Punjab Rev. Svy. [443].	from Mackinnon's Sch. Msrl.
TODD, Wm. b. c. 25–11–38.	11–1–56 Calcutta	Pindi & Kashmir topo., 1856–62; Gwalior, 1863–4; Kumaun, 1864–8; Kāthiāwār, 1869–6; Calcutta DO. & DDn. comp., 1874–5; Kumaun, 1877; ch. Bombay topo 1878 Calcutta DO. 1879 till ret. aged 55, 25–11–93.	
TURNBULL, Wm. Henry [III, 386; IV, 386] b. c. Sept. 1810. d., in fd., Orissa, 24–4–53.	27–3–27 Madras	Hdbd. topo., 1830–50; Orissa topo., 1850, till death.	son of Thos. [II, 352; III, 508]; m., Scdbd. 14–6–38, Leonora Sarah Ficker; dau. m., Peter, son of Andrew Chamarett, senr. [430].
VANDERPUTT, John Alex. b. c. May 1839. d., Agra, 1878/9; ML.	1–9–56 Cuttack	Orissa, 1856–60; Chota Nāgpur, 1861–70; Gwalior, 1876 till death.	Eleanor Mary, his wife, d., Mssrl., 14–7–71.
WILSON, Alfred John b., 10–4–45. d., Poona, 18–6–81; MI.	1–10–60 Calcutta	Calcutta DO.; from 1–1–60; No. 4 Party, Topo; Central India & Rajputana DO. Calcutta, 1873. 1877, with No. 2 Party, Topo; Khandesh & Bom. Calcutta Dm. 26–6–80. Dehra Dun DO. STS.; 1–10–85; 11 Party Burma, 1–11–89. Calcutta DO., 18–2–92. 21 Party Burma, 1–11–94. To Gazetted rank; 18–8–1892.	pr. son of Wm. [IV, 475; V. 444]; m., before 1870, Amanda Maria.
WYATT, Alex. Geo b. c. 27–2–45.	24–1–61	appce. dmn.; SAS. 11–1–61.	pr. son of Alex. [444, 543].

CHAPTER XXVII

CIVIL ASSISTANTS: REVENUE SURVEYS

Appointments — Successful Careers — The Lesser Fry — Nominal Rolls: Bengal — Bombay — Madras.

IN 1842 the revenue surveys of the North-Western and Lower Provinces of Bengal—except three in Bihār and one in Midnapore—were closed down, and in 1844 there were only about twenty assistants remaining in employment. Whilst occasional appointments were made to replace casualties, it was not until after the first Sikh War of 1845–6 that recruitment was reopened for new surveys in Upper India, Rohilkhand, and the Punjab. For this purpose volunteers were transferred from Lower Bengal, re-appointments made from those discharged in 1842, and new men found up country.

As there were no young military officers available[1], executive charge of three of these surveys was now entrusted to experienced civil assistants. Alexander Wyatt was recalled to relieve Maxwell when that officer resigned in 1844, and James Pemberton superseded Fitzpatrick the following year [241, 244, 441]. Both did well but died early and were followed by Nicholas Davey and Robert Smart who proved equally successful. Another Bihār assistant who did well was James O'Donel, who held charge in Arakan, the Chittagong Hills and Lower Assam. Wilson who took over the Midnapore party when Mathison retired in 1844 was not a success [247, 434].

The distribution of assistants between the various parties in 1848 stood thus;

No. 1, or North Division, under Pemberton:—O'Donel; J. R. Pringle; C. Mullins; A. Smith; R. Smith; Ewan.

No. 2, or South Division, under Smyth:—N. T. Davey; W. R. Pringle; Otto; W. Davey; Willis; May.

No. 3, or East Division, under Wyatt:—Bridge; Bell; Heysham; Campbell; Pickel; Anderson; Adam.

No. 4, or West Division, under Tickell, acting for Sherwill:—W. R. Chill; Brady; G. Swiney; Parker; Robert Smart; Lallah Ram; Pickard; Geo. Thompson; Arthur Smart; David.

Delhi & Rohilkhand under Donald Vanrenen with Burgess as Assistant:—Hoppner; D. Blyth; W. Sanderson; Edward Johnson; Sergt. Millard; J. H. Gibson.

Punjab; cis-Sutlej, under Stephen:—C. Foy; Kavanagh; A. B. Blaney; Burrowes; Loftie; Housden; A. Foy.

trans-Sutlej, under Blagrave:—W. Blyth; W. Lane; Permien; Ellison; G. H. Blyth; Harris.

Thuillier could not control recruitment for the up-country surveys [349–50];

> Captain T. C. Blagrave has been in the habit of discharging his assistants and sub-assistants ad libitum without reference to this office. On one occasion no less than three sub-assistants were discharged, and three taken in their place in the middle of a field season. These Punjab establishments having originally been formed from drafts from the Bengal surveys, the sub-assistants naturally looked to this office for protection, and appealed to me for further employment in the Department. ... No Department can hold together under...such a system.
>
> My duty with regard to the Punjab surveys has been a most invidious one, and it has been a difficult task to maintain even the semblance of Departmental union and strength[2].

Salaries had been fixed at the time of the 1833 conference [IV, 213, 364];

Apprentices from Rs. 50 to 80 per mensem.

Sub-Assistants Rs. 150 p.m.; Senior Sub-Assistants, Rs. 200 p.m.

[1] Afghān Wars, 1839–42. [2] DDn. 624 (73), DSG. to SG., 5–4–56.

Assistant Revenue Surveyor Rs. 250 p.m.; when officiating Revenue Surveyors in charge of survey, Rs. 388 p. m.[1].

Recruits could be engaged temporarily as *mutsuddis*, native surveyors, or office assistants, and brought on to the pensionable lists as 4th grade sub-assistants if and when they made good. There was no set interval for promotion from one grade to another. The Deputy Surveyor General had discretion to sanction promotions and increases of pay so long as he kept the expenditure of each party within its allotment. Extra allowances were allowed for service in Arakan and Sind.

A petition for a general travelling allowance @ Rs. 30 a month was not accepted [375–6], and Wyatt was allowed no allowance for his journey from Patna to Dacca when he moved his party from Bihār to East Bengal. On the other hand Adam was allowed boat allowance at the rate of two-thirds of his salary for his journey from Bengal to Ambāla. This was calculated to cover a period of 2½ months, at a rate of 10 miles a day for the distance of 762 miles [IV, 170].

The pay of the civilian gazetted and non-gazetted officers of the Bombay and Madras surveys was on a considerably higher scale.

SUCCESSFUL CAREERS

Two of the older assistants, Fitzpatrick and Wilson [IV, 395–6], failed to stand up to the test of executive charge. Fitzpatrick did well in Balasore but failed in Purnea. Mathison had recommended Wilson as being perfectly competent to conduct any survey, but...greatly deficient in energy and moral courage. The heavy responsibility will, however, soon teach...the necessity of acting and thinking for himself and, as he is a man of the highest principles and integrity, I have no hesitation in recording my opinion that the Hooghly survey will proceed satisfactorily under his superintendence[2].

Unfortunately Wilson's lack of close control led to serious errors in both Burdwān and Hooghly districts, and led to his discharge in January 1848 [304]. Some years later, in 1856, he was re-employed as a senior assistant in one of the Central Province parties until, in 1860, "being no longer equal to the very hard work... in such a hilly and jungly country, he was transferred to the new party raised for Oude". His son, William Alexander, was appointed to the same party in January 1861, and promoted to gazetted rank in 1892.

Alexander Wyatt had started as surveyor under the Collector of north Moradābād in 1824 [III, 154–5], and was transferred to the survey department in 1827. Discharged in 1842, he was selected in 1844 for charge of the Sāran survey. After working eastward, first into Tirhut, and then to Mymensingh, his health broke down in February 1857 as the result of a stroke. "Thorough master of all the details of his profession, and one who had considerable administrative abilities, he was also an excellent revenue officer and linguist"[3].

Pemberton had been a protegé of Henry Lawrence and joined the N.W.P. surveys in 1835 [IV, 390]. He had done well from the start and had been selected from Sherwill's party in 1845 to take over charge of the Purnea survey from Fitzpatrick [244]. After working east through north Bengal his health broke down during the survey of Dinājpur, and he died at Darjeeling in 1860.

James O'Donel had first joined in Orissa in 1836, and was holding charge of the Purnea–Rajmahāl detachment when surveys were closed down in 1842. He fully justified his retention in the Department, and during 1848 did much to clean up the disorder into which the Bhāgalpur party fell during Sherwill's absence on furlough [304–5]. In December 1853, he took over the Goālpara survey on Kelso's retirement [242], rejoining Pemberton's party on completion of the work a year later. In 1855 he was given charge of the Arakan survey which involved topographical survey of the extensive forest areas combined with large-scale revenue survey of

[1] DDn. 472 (27), DSG. to SG., 22–2–47. [2] DLR., 37/49 (49), Mathison to DSG., 7–8–44. [3] from DSG., 31–3–58.

the cultivated tracts. He then extended survey into the Chittagong Hill tracts [243]. "Mr. O'Donel is an able officer who has shown great tact and judgement in conducting these operations, and his name will long be associated with the exploration of a great deal of our eastern possessions, before quite unknown"[1]. He was appointed "Surveyor of the 1st grade" from 1st June 1866 and was in charge of the survey of Cooch-Behār when he died in the field in April 1872.

Discharged in 1842 after ten years service, Edward Hoppner joined the Sind survey in 1843 [276] and in 1847 followed Vanrenen to Rohilkhand;

Mr. E. W. Hoppner...has had extended experience, understands his work right well, and is particularly au fait in drawing aud compiling maps. He is...remarkably trustworthy and honest. The Scinde climate has sadly impaired his energies, and he is now very nearly used up[2].

He was selected in 1856 to succeed Alexander Daniell in charge of the Revenue Survey office in Calcutta, and held the post till 1862.

William Lane, brother to Charles of the G.T.S., had joined in 1837, and got into trouble more than once for absence without leave [IV, 399], but was re-appointed in 1844 and posted to the Tirhut survey. He resigned two years later on account of ill-health and from 1846 served in the Punjab holding charge of a camp in Thomas Blagrave's party in the Kāngra hills [271], where he attracted Waugh's attention by his "great natural talent for topographical drawing";

I think if that gentleman was to join Lieutenant Robinson for a little while he would soon acquire a knowledge of our principles of delineating ground. ... I compiled the degree sheet partly from our topographical sections, and partly from the Kangra revenue survey. ... The revenue survey...stood that test very well [217, 318][3].

In 1856 he accompanied Macdonald to Sind, where he was given an independent charge. He later held charge of various revenue surveys till he retired in 1876.

Nicholas Davey joined the Midnapore survey in 1841 and won praise from Smyth for his work in the 24-Parganas. He relieved Wyatt on the Mymensingh survey in 1857, succeeding to substantive charge later in the year. The modern system of cadastral survey was first tried out by Davey before 1870[4]. He died in 1873 whilst holding charge of the cadastral survey of Midnapore [247].

Charles Foy had a long record of good work, having joined as apprentice in January 1821 [III, 361 n.7, 371], and served in the north-western districts fifteen years till his discharge in 1842. He was re-engaged for work on the Kaithal survey under Brown and Saunders Abbott, and held charge of a camp under Stephen in the cis-Sutlej Punjab. He dropped out before 1855.

Three brothers, William, Daniel, and George, sons of Conductor John Blyth of the Allahābād arsenal, all did the revenue survey well. William and Daniel accompanied Stephen to Bihār in 1841 and in 1847 William rejoined Stephen on the cis-Sutlej survey, whilst Daniel went to Vanrenen's party in Ajmer and accompanied him to Rohilkhand. "Mr. Daniel Blyth" writes Vanrenen,

though uneducated, is a first rate office hand in all matters connected with the revenue survey. For this he has an instinctive talent, and is a hard-working, steady man. The evil effects of bringing him up to one particular line of duties is lamentably apparent. He has no idea of the most easy adjustment of surveying instruments, and cannot make out a scale for himself[5].

Whilst Daniel perished with Burgess' party at Jhānsi when all its Europeans were massacred in 1857, William resigned in 1855 for a successful career in the uncovenanted civil service of the Punjab. The younger brother George had joined the trans-Sutlej survey in 1847 and accompanied Thompson to Chota Nāgpur in 1859. In 1861 he deserted to more profitable employment with the Punjab Police; "I do not consider myself bound to serve any longer. As I have disposed of my horses—tents—in fact all my property—and made every arrangement for a move, ... I propose leaving the station on that date". The Surveyor General took the matter up; and the appointment to the Police was cancelled. Two years later he was humbly beseeching re-instatement, and he was still serving in 1877[6].

[1] *Rev. Report, 1863-4* (appx. p. xxiii). [2] DDn. 485 (A. 18), 12-12-49. [3] DDn. 625 (63), SG. to DSG., 21-6-55. [4] *GR Rev. LP. 1870-1* (36); from Macdonald, 30-10-71. [5] DDn. 485 (A. 18), to DSG., 12-12-49. [6] DDn. 43 (120-204), 12-8-61 to 18-6-63.

John Charles Kavanagh was posted to the cis-Sutlej survey in 1846 as Assistant Surveyor in charge of a camp[1]. After Stephen's departure he was left with a small section to complete the survey and prepare the necessary maps, which occupied him till 1855 [270]. After a short time with Shortrede's party on the Jech and Sind Sāgar surveys [273–4], he obtained appointment to the uncovenanted civil service of Oudh, which had been taken over by the British in February 1856.

Edward Johnson was elder brother to William Henry of the G.T.S., and was educated at Mackinnon's school at Mussoorie [402]. He was posted to Vanrenen's Ajmer party in 1847 and accompanied it to Rohilkhand. In 1854 he was temporarily lent to the Nimach survey under Dennys, and then rejoined Vanrenen in Jubbulpore, [266, 268]. From 1862 he held charge of various district surveys until his superannuation in 1883.

George Housden joined the cis-Sutlej survey in 1846 and accompanied Shortrede to the Upper Rechna *doāb* in 1852 [273]. He spent the whole of his service in the western Punjab and on the North-West Frontier till his retirement in 1879. He sent four of his sons to Stokes' school at Mussoorie.

James Campbell joined Wyatt's party at Patna in 1844 and transferred to the Rohilkhand party in 1850. His father, a sergeant in the Commissariat at Ambāla, had written to the Assistant Adjutant-General at Calcutta asking that "as a good turn to an old soldier" he should persuade the Deputy Surveyor General to arrange this transfer as Dacca was "undermining" his son's health. Campbell accompanied Vanrenen to the Central Provinces and held charge of various revenue and topographical parties from 1865 to 1881.

Robert Smart joined Sherwill's party in Bihār in 1846, and was joined the following year by his brother Arthur. Thuillier reports in April 1859 that

> the brothers Smart are as good in office as in the field; excellent draughtsmen and printers, ready and trusty calculators and observers. When this is added to the most upright and correct personal demeanour and cheerful disposition, greater praise could not well be bestowed[2].

Posted to charge of No. 1 Division at Dināpur after Pemberton's death, and promoted Revenue Surveyor in the senior branch from July 1862, Robert retired at the age of 55 in 1882.

Frederick Kelly joined the Punjab surveys at the end of 1854, and then moved to Sind. After later service in Bundelkhand and Oudh he spent some time as Head Draughtsman at Dehra Dūn and Simla, and in 1883 joined the revenue survey party in Burma, being promoted to the senior branch that year. After retirement in 1890 he accepted a survey post in the Strait Settlements.

Amongst the younger men who rose to charge of parties and served on till superannuated were Henry Talbot who had started on topographical surveys in the Himālaya and the Punjab—William Patterson and Charles Campbell who joined in the Punjab in 1851 and 1853—Frederick Grant and William Vyall who joined in the Central Provinces in 1856 from the Thomason College at Roorkee. Vyall died at Rangoon in 1888 whilst serving with the Burma revenue survey party and Grant five years later after a special extension of service.

THE LESSER FRY

Appointments to revenue survey were made to no fixed establishment, and at no periodical intervals. There were no regular tests or examinations as in the trigonometrical and topographical surveys. Revenue survey parties were liable to unforeseen retrenchments, or equally unforeseen creation. Assistants had to be picked up when and where available, and Calcutta was by far the best source of recruitment; either from its many schools, or from young men arriving from overseas in search of employment. Officers up-country had many opportunities of finding young men anxious for a job, even if they had no technical

[1] DDn. 624 (51), DSG. to SG., 5–4–56. [2] *GR. LP.*, from DSG., 2–4–59 (57–8).

qualifications. Some were unsuited to any sort of professional work or to any regular discipline and there were frequent cases of misfits, misconduct, absconding. Many promising recruits found early opportunity for bettering themselves, but on the other hand many gave long and devoted service to the Department [405].

John Adam reached India at the age of 23 after employment as a bank clerk in Scotland and in 1848 was engaged for Wyatt's party in Bihār ;

After finishing my education in Scotland, I went under indentures to...the Union Bank of Scotland. ... I remained for six years, when I came out to India in 1841 as assistant to a mercantile house in Calcutta. ... In 1845 when I was on a salary of Rs. 360 p.m. one of the partners was taken ill with cholera and died, and the other determined on...going back to England. I was...thrown out of employment. ... I joined the East India Railway...Civil Engineering Institution where I remained for two years. ... I received no salary from the Company, but maintained myself from what I had previously. ...

You were kind enough to appoint me as a third-class sub-assistant on the Tirhoot survey upon a salary of Rs. 75 a month[1].

Adam was short of cash and Thuillier reported that the commander of

the steam vessel *Nerbudda* claims from Mr. J. Adam...the balance of messing and wines and beer supplied during the voyage from Calcutta to Sitapore. ... You will be good enough to remit...Rs. 73–12 to this office, deducting the same from Mr. Adam's next issue of pay. ... The transaction...is viewed with much dissatisfaction, more especially as the expense...for wines and beer, Rs. 49, for a period of about 15 days, shews a very unnecessary extravagance.

In sending the remittance Wyatt pointed out that Adam had already paid Rs. 24 before leaving the boat, and had always intended paying the balance as soon as he drew his pay[2]. A year later he was promoted to Rs. 100 and transferred to the cis-Sutlej survey. He was no longer on the survey roll of 1855.

Burgess lost a promising recruit in St. George who had joined in Rohilkhand from a Dragoon regiment [443] ;

His leaving me to take employment more congenial to his taste...at Shahjehanpoor was by his own desire. ... He is a neat draftsman...and expeditious, but his chief...[talent lay] in architectural design and drawing, in which I have met with few or any equal to him in this country. .... He has had great experience both in England and America, and is much acquainted with his duties as a surveyor, though of course our...[procedure] was new to him[3].

St. George resigned for service on the Railways with salary "precisely four times the amount he was then receiving". One would welcome the story of how a man with such qualifications came to be serving with a cavalry regiment in India[4].

Thuillier engaged William Stevens for Gastrell's party in 1856,

a young gentleman of respectable family and education who has lately arrived from England; tested by examination ; possesses the precise qualifications adapted to our wants. Has signed the usual 3-year agreement ; appointed on Rs. 100 from 20th May 1856 ; ordered to Berhampore. ... Has lately been employed in the Bengal Marine service ; a knowledge of the language yet to be acquired ; applies for appointment in Great Trigonometrical Survey.

His resignation within the 3-year period was refused and he absconded on 14th October 1858. He suffered from "a dislike of being checked, backed by a strong will", and "deserted for the ostensible object of joining one of Messrs Jardine & Skinner's silk factories, but when they heard of the circumstances they declined to have anything to do with him"[5].

Our old friend William Chill, reappears in 1846 [IV, 391–2]. He explains the reasons which drove him to Sind after break-up of the N.W.P., surveys ;

Thrown out of employment, and unable for near two years to get any place but that of a section writer on which to support a large family ; possessed of no interest, and having no friends on whose exertions...to rely for a place in Hindoostan, I was driven by great distress to accept an appointment in Scinde, ... though the country was distant and excessively dear, and my going there involved great expense and...separation from my family, and though... a much my junior was there on a higher salary[6].

After four years at Karāchi he begged Wyatt to arrange his return to Bengal ;

[1] DDn. 36/27 (193–4), to DSG., 10–7–49. [2] DLR. 37/56 (2, 211), DSG. to Wyatt, 29–4–& 20–5–48 ; 37/58 (257), Wyatt to DSG., 13–5–48. [3] DDn. 485 (54). [4] DDn. 624 (45), DSG. to SG., 5–4–56. [5] DLR. 36/25 (116–7), DSG. to Gastrell, 2–6–56 ; BRC. LP., 1857–8 (57–8), from DSG., 2–4–59. [6] Nathaniel Hodges also with Sind svy., but senior to Chill ; [IV, 398] DLR. 37/58 (137), 1–7–47.

He complains of the climate of Scinde and his separation from his family who are...in Calcutta, and is desirous of...transfer to Bengal on a lower grade, even Rs. 150, ... in exchange for Rs. 250 which he now draws in Scinde. ... I have no wish for him on this survey[1].

Wyatt was however persuaded to accept him in place of Lane who had just resigned [435]. Leaving Karāchi in the middle of November, Chill reached Barmer, 80 miles west of Abu, on 12th December, arriving there

after a tedious march across the desert. ... I intend starting immediately for Nusserabad. Thence I go through Dholpoor to Calpee, where I take boat and proceed to Mirzapoor, and as I march from twenty to twenty-four miles daily I hope to reach it quickly. ... I intended proceeding to Mirzapoor via Baroda, but...[was] advised...not to take that route. ... I should have preferred going by sea to the great fatigue of marching by land, but I wanted the means. ...

Ajmer, 28-12-46 ; I reached this place late last night. A fever detained me a few days after passing Pallee[2]. I leave this immediately for Kalpee.

When I wrote to you from Kurrachee I mentioned a month and twenty-six days as the time it was likely to take me in reaching Calcutta. ... I was very much misinformed. ... It will take me...another twenty days to be at Mirzapoor, and I have already been a month and 11 or 12 days. ... I have been exerting myself—to the injury of my camels and my own and servants' health—to make a quick passage. ... I have had two attacks of illness, and still feel the effects of the last fever. ... The illness has been owing entirely to...the sun and night dews[3].

Calpee, 27-1-47 ; I have just reached this station. I left Ajmeer after writing to you on the 28th, and pursued my way towards this place via Dholpoor. I reached Dholpoor on the 12th instant. As I had been ill on the way and still continued ailing, and as my small stock of medicines was out, and my supply of money reduced to a couple of rupees, I ventured to change my route, and...went to Agra which was but two days march, and took boat there.

I reached Agra on the night of the 13th, and only waited time enough to have a few suits of clothing washed, leaving it on the morning of the 16th. ... In so long a journey many circumstances will arise to a man with such limited resources as mine have been. ... If my camels broke down with fatigue I was [compelled] to await their recovery...because I had not the means to get others. If my men or I fell ill, I was obliged to halt for want of a dhooly. ... Scarce a week passed without the loss of a day or two[4].

He reached Allahābād on 7th February and joined Wyatt, at Patna, on 28th. In September he was transferred to Sherwill's party and his inertia when in charge of the traverse computations resulted in the passing of very serious blunders, and even fraudulent work [255, 304-5]. Sherwill reported that he

neither possesses energy or application, nor apparent liking for his work, to constitute an efficient active surveyor. Mr. Chill appears to possess a dreamy, uncollected, unintelligent... mind. He can never readily answer any question relating to his work ; appears to know very little about work performed by his subordinates. ... Mr. Chill is totally useless to me. ...

Mr. Chill...has, after three whole months labour completed 40 square miles, an area that would occupy the same establishment under any other of my assistants about three weeks. ... I positively can never give him a camp again. It is a farce attempting to get him to look after *anything* in the shape of work. What are we going to do with him[5] ?

His resignation was accepted the following year and he found employment with the Customs Department in Calcutta.

The demons of extravagance and debt laid stranglehold on many an excellent assistant, and Wroughton complained to Wilson, whose party was working within a few miles of Calcutta, of his assistants "being constantly in Calcutta, with or without your permission. A visitation to this place without my express permission is not only irregular; but will...draw considerable discredit on the party who may violate this order"[6]. Just before shifting his party to Dacca Wyatt found that his senior assistant John Bridge [440] was so much

in debt that his creditors will not allow him to leave this station until he can make some arrangements for paying them. ... If he be detained by civil process for debt he will render himself...[liable] to loss of appointment. He has applied for six months leave of absence[7].

The creditors were met, but less than two years later Bridge died at Mymensingh leaving Wyatt to lament "the loss of that able and experienced assistant". Some years later a son of the same name joined the Aracan revenue survey.

[1] DLR. 36/31 (53), Wyatt to DSG., 6-2-56. [2] Pali, 40 m. s. of Jodhpur. [3] DLR. 37/58 (7, 9), 12 & 28-12-46. [4] ib. (24). [5] DLR. 37/57 (21); 15-1-49; 63 (228), 5-3-50. [6] DLR. 37/50 (19), 22-4-45. [7] DLR. 36/33 (54), Wyatt to DSG., 16-10-49.

We conclude with one of the tragedies inseparable from life in the wilds. In 1850 Pemberton reported the tragic death of Anthony Smith, who had first joined the survey in 1837, drowned in a river in Purnea District ;

On Sunday 31st ult., Mr. Smith went to Mr. O'Donel's tent and asked him to come and have a bathe in the river which...is 150 yards wide and very deep, in places 30 feet. Mr. O'Donel objected, stating...that it was a great deal too hot ; Mr. Smith then said, "Very well, I'll go and have a swim and be back immediately for breakfast. He went to the ghat attended by three or four of his servants, bathed, swam about close to the shore, came out of the water, partially dried himself, combed his hair, and then plunged into the river again and swam off, as if intending to go to the opposite bank. His servants describe his swimming as if in a race. About the middle of the river he decreased his speed, and when within twenty yards of the opposite bank he was seen suddenly to lift his arms out of the water and sink without a struggle.

His servants thought he was trying to touch bottom, or had dived as he had done before two or three times when crossing, but he never rose to the surface again until dragged up by the net three hours after. Strange to say, when his body was found it did not appear that he had swallowed any water ; the mouth was firmly shut. The doctor is of opinion...that he had ruptured his spleen by the exertion of swimming, as he was much subject to attacks of spleen[1].

NOMINAL ROLL : BENGAL

Name, Birth, Death	Appointed	Employment	Domestic
ADAM, John b., Scotland, 1818/9 arrd. India, 1841.	25-2-48 Calcutta	Tirhut, 1848-9 ; cis-Sutlej, 1849-50 ; resd. before 1855.	from Bank in Scotland with merchs. Calcutta 1841-5 ; MIR. Eng. Inst., 1846-8.
AGABEG, Paul b., England, 1831/2	1-12-51 Calcutta	24-Parg. & Nadia, 1851-6 ; resd. 23-12-56 ; to England, 1856-60 ; re-appd., 18-1-60 ; Sylhet, 1860 till resd. 2-11-63.	ed., 7 y., Denmark Hill, London.
ANDERSON, James G. b., Scotland, 1829/30 arrd. India, 1846.	11-11-47 Mzfrpr.	Tirhut, 1847 till resd., 15-6-49.	ed. Merchiston, Scotland ; black edged appn. for svy. appt. 17-10-47.
ARATOON, J. T.	1-12-56 Dacca	E. Bengal, 1856-65.	ed. Dacca Coll.
ATTS, Chas. ed. as civ. engr.	19-3-56 Agra	from rlwys. ; Brtpr., 1856 till resd. for empt. on rlwys.	son of Francis ; m., Agra, 7-1-57, Isabella Rose, dau. of John Anthony.
BARCLAY, Robt. b. c., 25-6-41 ed. La Martinière, Calcutta.	20-9-56 Calcutta	Mmnsg. & E. Bengal 1856-65 ; Manbhum Burma, & Cooch Behár, 1866-70 ; furl to England 1867-8 & 1869-70 ; Mrdbd., 1870-1.	of Euro. parents, both dead 1856 ; Guardian, Rev. T. Morgan, Calcutta.
BEATSON, W. H.	1-10-52 Calcutta	N. Bengal & Dacca, 1852 till resd. 3-1-60.	
BELL, Chas. H. [III, 370 ; IV, 397] b. 1810/1.	1-12-26 Calcutta	NWP., 1827-43 ; N. Bihár, 1844-51 ; E. Bengal, 1851 till pension 1-1-59.	nat. son of Geo. Banks B. (1786-1847), Ben. Inf. ; 2 sons emp. as *mutsuddis* from 1855.
BENNETT, W. H. kd. by mutineers, Jhánsi, 8-6-57.	1-1-48	Delhi & Rhtkd. 1848-50 ; trans-Sutlej, 1850-1 ; Bdlkd., 1853 till death.	
BERKELEY, S.		Punjab, 1852-5.	
BILLON, Benjamin Henry b., 21-9-38 ; bapt., (adult) Simla, 11-10-57.	1-6-52	Punjab, 1852-9 ; passed exam. for SAS. June 1859 ; Ch. Ngpr. 1859-66 ; Hooghly, 1866-7 ; Calcutta Sbbs. 1868 till ret. before, 1878.	son of Emile [*inf*] & Harriet ; pr. bro.-in-law to Andrew Olliver [359].
BILLON, Emile	Oct. 1855	dmn. Punjab to 1859 ; Ch. Ngpr., 1859 till resd., 1-1-60.	father of Benjamin (*sup*) and husband of Harriet.
BLANEY, Arthur B. d. 1851 [IV, 399].	Nov. 183	Bengal & Assam, 1838 till disch. 1842 ; Punjab, 1847 till death.	pr. son of Condr. Peter B. ; bro. to Chas. (*inf*).
BLANEY, Chas. A. [IV, 397]	1-11-35	NWP. & Orissa, 1835 till disch., 1842 ; drew plan for Allbd. ch. ; MRIO. 17 (59).	m., Chunár, 8-10-44 ; Mrs. M. Whiffen.
BLYTH, Daniel Thos. [IV, 397] b. c., 1820 ; kd. by mutineers, Jhánsi, with w., m.-in-law, & 3 ch.	1-10-36 Allbd. 8-6-57	NWP., 1833-41 ; Bihár, 1841-7 ; Ajmer & Rhtkd., 1847-53 ; Bdlkd., 1853 till death.	son of Condr. John B., of Allbd. ; bro. to Geo. & Wm. (*inf*) ; m., Caroline before 1852.
BLYTH, Geo. Henry b. c., 1-10-29.	1-12-46 Allbd.	Punjab, 1847-59 ; Ch. Ngpr. 1859 till resd., 1861 ; re-appd., 1-5-62 ; Oudh, 1862-5 ; Bengal, 1865-70 ; Punjab, 1871-78.	m., 2nd., Masri, 30-10-75, Jane Maria wid. of Sgt. H. Wray of Mrdbd. rev. svy. dau. of Thos. West & who d. of cholera, Naini Tal, June 1878.
BLYTH, J.		OP., 1854 till disch., 1855.	pr. bro. to above.
BLYTH, Wm. Edw. [IV, 397] b., June 1818.	1-1-34 Allbd.	NWP., 1834-41 ; Bihár, 1841-7 ; Punjab, 1847 till resd. for uncov. civ. Punjab.	m., Grpr, 30-8-39, Charlotte M. Chamberlane ; 2nd., Amritsar, 28-11-57, Sarah Hunter, wid., dau. of M. O'Conner.
BOLST, Geo. Chapman	15-10-50	dmn., E. Bengal, 1850-6 ; SAS., 1856-8 ; drawing max. Rs. 150 as office asst., 1867.	son of Wm. Henry & Mary of Calcutta ; bro. to Wm. C. & H. J. [350, 430] ; m., Dacca, 16-9-57, Helen Eugenia, dau. of Geo. Kallonas.

[1] DLR. 36/18 (161), to DSG., 3-4-50.

Name, Birth, Death	Appointed	Employment	Domestic
BOLTON, W. H.	6-1-54	Punjab, 1854–6; Sind, 1856 till resd. 1864 for Sett. Dept.; "great loss to Survey".	possibly Boulton (*inf*).
BONNY, A. F.	11-9-54	Ngpr. & CP., 1864 till resd., 2-7-64.	bro. to G. B. (*inf*).
BONNY, G.	1-2-55	Ngpr. & CP. till resd., 8-11-64.	bro. to A. F. B. (*sup*).
BOULTON	Dec. 1851	Rhlkd., 1851 till resd., Feb. 1852, "very promising".	
BRADLEY, Chas. [IV, 397] b., 1805/6 arrd. India, 1818/4; d., 27-9-60.	18-11-38	NWP., 1838–41; Bihār, 1841–53; Bengal, 1853 till death.	m., Catherine before 1842; father of W. E. B. [*inf*].
BRADLEY, W. E. d., 13-7-63.	1859	Frdpr, 1859–60; Sylhet, 1860 till death.	son of Chas. (*sup*).
BRADY, Peter Henry Wm. b. c., 20-10-48.	1-2-60	dmn. Calcutta DO., 28-8-59; Ch. Ngpr. & CP. 1860–71; SGO. 1870.	
BRENNAN, P. M.	18-12-58	Bdlkd. & CP., 1858–64; Oudh & CP. 1864 till dism., 24-7-67.	
BRIDGE, John, senr. [IV, 397] b., 1808-9 d., Mmnsg., 1851.	Oct. 1828	NWP. 1828–41; Bihār, 1841–50; E. Bengal, 1850 till death.	father of John (*inf*).
BRIDGE, John, junr.	15-1-58	Arakan, 1858–63. offg. asst. & dmn. Punjab, 1864–5.	son of John (*sup*).
BROCKMAN, W. D.	28-9-56	N. Bengal, 1856–60; Tippera, 1860–3; L. Assam, 1863–71; Calcutta DO., 1877.	from La Martinière Sch., Calcutta.
BROWNFIELD, Constantine P. b. c. 1840.	3-11-52	N. Bengal, 1852–60; Tippera, 1860–3; L. Assam, 1863–6.	
BURNETT, Duncan Welland	21-12-46	Punjab & CP., 1847–61.	
BURROWES, J. J.	1-11-55	Punjab & Oudh, 1855–68; leave mc., 1868–9; Ch. Ngpr. & CP. 1869–72. Irrgn. Svy. W. Son, 1873 till struck off 21-11-76 absent wl.	bro. to Wm. Samuel (*inf*).
BUTTRESS, Geo. Robt. b. c., 15-7-40.			
BUTTRESS, Wm. Samuel b., 19-2-44.	1-9-60	Oudh, & CP., 1866–9; NWP. 1869–74; Punjab, 1884; still serving 1892.	bro. to Geo. (*sup*).
CAMPBELL, C. H.	...	Dacca, 1855.	
CAMPBELL, Chas. Wm. b. c., 1-5-31.	1-11-53	Punjab, 1855–9; Oudh, 1859–70; NWP., 1871–8; ret. on pension, 31-10-82.	
CAMPBELL, James b., England c., Jan. 1828; arrd. India, 1832.	8-10-44	from Med. Dept.; Tirhut & Mmnsg., 1844–50; Rhlkd., 1850–3; CP., 1853–64; NWP., 1865–70; in ch. Bwlpr., 1871–3; Bengal, 1873–7; leave in India, 1877–8; in ch. Orissa, 1879 till furl. India, 1881.	son of Sgt. James C. of Commt.; parents at Ambāla 1850, took ch. of his w. & child.
CHILL, Wm. Richd. [III, 371; IV, 397] b., 3-6-09.	4-12-23	NWP., till disch. 1842; Rev. Bd. Allbd., 1842–4; Sind 1844–6; Bihār, 1847 till resd., 1851, for Customs, Calcutta.	5th son of Lt. Commy Sem. C., m. Mrfpr. 5-8-32, Indiana Clarke.
CLINE, G.	24-12-55	CP., 1855–8.	
COMYN, Geo. [III, 371; IV, 397] b., 6-2-08.	4-12-23	NWP., till dism. 1834; dmn. PWD., Jblpr.; reemp., Bihār 1841 till ret. 5-4-46.	son of Lt.-Col. P. T. C. (1780–1832), Ben. Inf.
COOPER, J.	1856 Amritsar ...	Punjab.	ed. La Martinière Calcutta resdg. Amritsar.
CORNISH, P. C.		office asst., No. 4, Div., LP. till resd., 1-11-54.	
COWLEY, Pat. Aug. Geo. b. c., 15-1-42.	1-9-59	CP., 1859–62; Drjlg, 1863; Bwlpr., & Punjab, 1868–72; NWP. 1873; Bihār, 1877–81; furl. to England, 1882–3; ch. Chtsgr., 1883–5; leave on mc., 1886–8.	son of Maj. C. W. C. (1793–1848), Ben. Inf.
DANIELL, Alex. [IV, 397] b., 1812/3 d., Calcutta, 19-4-55.	Oct. 1834	NWP., 1834 till disch. 1842; Hd. Asst. DSG.'s office, Calcutta, 1844 till death.	
D'ANSELME	...	N. Bengal, 1859–60; absent wl.	
DAVEY, Nicholas Thos. [IV, 399] b. c., 18-12-23. d. 4-3-78, "jungle fever"	7-2-41	Bengal, LP., 1841–57, incl. Sylhet-Tippera bdy., 1850; ch. E. Bengal, 1857; furl. to England, 1868–70; Hooghly & Mdnpr. 1871 till death.	2-2-60; w. MarthaMary d. in childbirth, Serampore; member of ASB.
DAVEY, Wm. b., 1827/8 arrd. India, 1829.	1-12-47	from Preventive Offr. Customs; Bengal, LP., 1847 till resd. 31-10-57, to become Dep. Collr.	bro. to Nich. (*sup*); m., before 1852.
DAVID, Chas. b. c., Jan. 1828.	1-9-47	Bihār & Bengal LP., dmn. & *mutruddi*, 1847–56; SAS. Assam 1866–70; Calcutta DO., 1869–70 Cooch Bhr., 1876–7; Orissa, 1878 till ret. on pension, 1-1-80; on bdy. svy. Mālda after ret.	
DAVIOTT, J.	1-2-54	N. Bengal, 1854–60.	
DENTY, James Henry [IV, 399]	1838	Orissa, Bihār, L. Assam, till dism., 18-5-51.	
DERRMO	1854 Nimach ...	Rājputāna, 1854 till disch., 1-11-55.	
DE SILVA [IV, 397]		NWP., 1835–6; Bihār, 1846–7; Rjptna, 1847–8.	
DE VERIA, Louis	15-11-59	N. Bengal, 1859–60.	pr. bro. to Jules, GTS [418].
DE DOMBAL, E. Michael Durup d., Masri., 16-7-79, aged 47.	10-8-49	24-Parg., 1849; till resd., 1-9-49; previous knowledge of rlwy. svy.	ed. King's Coll. London; 1862 Indigo Pl. Frdpr.; later Dist. Engr., Mmnsg.
DORAN, J.	13-11-55	dmn. CP., 1855.	
ELLISON, Wm. b., India; c. 1819 ed. England; arrd. India; 1843, to Indigo, c/o. Chas. Francis nr. Patna.	Nov. 1846	Tirhut, 1846–8; Punjab, 1848–59; Ch. Ngpr. 1859–60; CP., 1860 till dism., 24-7-67.	son of James, Senr. and pr. bro to James [419]; m. Jlndr., 17-2-49, Sophia Blyth, pr. dau. of Km to Wm. E. B.
EWAN, Thos Wm. b., 1831-2 arrd. India, 1832	1-12-47	N. Bengal till disch., 16-5-50.	son of Chas. & Sarah, both dead before 1847; ed. England & La Martinière, Calcutta.
FITZPATRICK, John [III, 371; IV, 413] b. c., Jan. 1806.	1-10-21	Rhlkd., 1821–37; ch. Balasore, 1837–42; 1837–42; Purnea, 1842 till resd., 1846, without pension.	son of Robt.; Dep. Commy m., Fgr, 26-5-34, Margaret Isabella Macklin, who d. Bangalore, 2-2-89.
FORBES, E.	1-4-49	Punjab, 1849–50.	
FORD, Robt. Benoni d. Goālpāra, Assam, 23-5-53, aged 16, ML Gauhāti.	1-11-51	L. Assam, 1851 till death; emp. as "*mutruddi*".	neph. of Sam. Fleming, who d., 16-5-35, aged 30; same ML

Name, Birth, Death	Appointed	Employment	Domestic
FOY, A.	2-7-47	Punjab, 1847-59; leave on mc. to England, 1860-1; Oudh, 1861 till resd. 4-11-61	pr. son of Chas. (*inf*).
FOY, Chas. Christopher [III, 371; IV, 398] b., Delhi, 25-12-09.	20-12-21	Bengal & NWP., 1821-42; Kaithal & Punjab, 1844-53.	son of Condr. Andrew F; m., 1st., Meerut, 23-8-30. Sarah Few; 2nd., Meerut, 15-10-35, Cecilia Templeton.
FOY, Edw.	7-2-55	Derajāt & NWP., 1855-60; NWP. & Sind, 1860-3; CP., 1863 till absent from 3-3-66.	pr. son of Chas. (*sup*).
GIBSON, Andrew John b. c., April 1842.	14-3-61	Derajāt & NWP., 1861-77; ret. 2-12-96 aged 55.	m., Julia Elizabeth before 1874.
GIBSON, J. H.	...	Rhtkd., 1848-50.	
GOMESS (GOMEZ), A. D. B.	1852/3	Geol. Svy. 1849-52; Rev. Svy. 1853-6; Dep. Collr. Sundarbans, 13-12-56; Comnr. 1866-84; Rlwys. Calcutta, 1884-9.	
GORE, J.	...	24-Parg., dmn., 1848 till disch., 1-12-49.	
GORE, Wm. Francis [III, 371; IV, 398] d., Mnghr., July 1846.	Nov. 1826	NWP., 1826-41; Bihār, 1842 till death.	son of Dep. Commy.; left one motherless child.
GOULD, Lewis	1849	24-Parg., 1849-52.	from Free Sch., Calcutta.
GRANT, Fredk. b. 14-8-36 d. Bangalore, 22-1-93	11-7-56	CP., 1856-75; Bihār, & Punjab, 1876-9; Pegu ch. Rev., 1881-4; CP. & Chtgg.; 1885 till sick leave after extn. 1892 ret. 12-10-92.	from Roorkee Coll.
GREEN, R. B.	...	Derajāt, NWP., 1859 till resd., 1-10-61.	both these Green's shown in same list; pr. bros.
GREEN, R. R.	13-8-58	Derajāt, NWP., 1858 till resd., 1-8-62.	
GUSTAVINSKI, Louis Thos.	1-1-50	*v.* Biographical Notes.	
HAMILTON	...	N. Bengal, 1858.	son of Lieut. H., Ben. Inf.
HARI SINGH b. *c.* March 1830 d., 29-5-74.	28-10-52	NWP. & Oudh till leave on mc. 21-7-73.	
HARRIS, Chas. Barrett	7-5-48	Punjab, 1848-51; Sind, 1858-62; later wr. in CE.'s office, Agra.	son of John; m., Simla 15-1-53 Elizabeth Webberly, dau. of D. C. B. Clarke.
HARRIS, J. W.	...	Sind, 1858-62.	
HEALY, Richd.	1-11-47	Bihār, 1847-50, as *mutsuddi*.	
HEYSHAM, Wm. [IV, 399] b. *c.*, March 1831	Sept. 1837	from asst. mr. Upper Orphan Sch., Kdrpr. to Orissa Rev. Svy., 1837-42; Bihār, 1844-8; 24-Parg. & Nadia 1848-51; "discontented, ... troublesome".	pr. son of Edm. (1787-1819) or Wm. (1796-1825), both Ben. Inf.; w. and 2 ch., 1845.
HODGES, Nathaniel [IV, 398] b. *c.*, March 1805.	17-1-23	Delhi, Punjab, & NWP., 1823 till disch., 1842; Sind, 1844 till ret., 1851.	son of Capt. A. H.; pr. Gdn. overseer, Benares, 1860.
HODGSON, G. J.		Sind, 1860.	
HODGSON, J. E.	1-11-53	Punjab & Sind, 1853 till resd., 9-3-66.	
HOPPNER, Edw. Wm. [IV, 399] b., 1812/3	1-10-31	Bengal, LP., 1831-42; Sind, 1843-6; Rhtkd., 1847-55; HA. & ch. Rev. Litho. Br. Calcutta, 1855-62 [359].	
HOPSON, J. G.	1-5-57	CP., 1857-60.	
HOWARD, R.	19-6-53	Punjab, 1853-4.	
HOUSDEN, Geo. P. b. *c.*, Jan. 1831.	18-2-47	Punjab, 1847-65; Derajāt, 1855-61; NWP., 1861 till ret. on pension, 1879.	4 sons ed. Stokes' Sch. 1868-81, incl. Alex. Prest (1864-90), Ben. Cav., *Punjab Inscr.* (173).
HYDE, Alfred b., England d., Rangoon, 8-9-64.	19-2-56	E. Bengal, 1856; Manbhum, 1860 till death.	
HYDE, G. b., England.	1-1-57	Bengal LP., 1857 till resd., 1-5-60.	pr. bro. to Alfred (*sup*).
IVEY, Wm. [IV, 399] b., 1820/1 d., DDn., 12-10-86; MI.	1837	Bengal LP., 1837 till dism. 1847; to England, 1847-9; re-appd., 1-12-49; Bengal LP., 1849-61; Drjlg. Tea Svy., 1862-3; CP., 1861-65; GTS., Oct. 1865 to June 1866; invd., 1-6-67.	m. before 1852.
JOHNSON, Edw. Thos. Smith	13-10-47	*v.* Biographical Notes.	
KAIN, Thos. [IV, 399] d., Sylhet, Jan. 1847.	1-4-39	Orissa & Sylhet, 1839; till disch., 1842; Mdopr. 1844-6; Sylhet-Tippera bdy., 1846 till death.	left wid.; his dau. m., Calcutta, 16-3-60, J. H. Poulson.
KAVANAGH, John Chas.	31-10-46	*v.* Biographical Notes.	
KEANE, J.	Feb. 1847	Punjab, 1847-53.	
KELLY, Fredk. Wm. b. 27-8-33	4-12-54	Sind, 1855-8; Bdlkd., 1858-60; CP., 1860-1; Oudh, 1861-6; ch. DO. & Comp., Rev. Svy. Calcutta, 1866-79; Burma Rev. Svy., 1883, holding ch. from 1887; ret., 27-8-90, after two extns.	
KELSO, John [IV, 399] b., 1803/4 d. Calcutta, before Aug. 1856.	17-1-37	Calcutta Town Svy. under Schalch, 1820-4; Mil. Bd. off. 1825-6; canals under Baker, 1826-7; occasl. Rev. Svys. 1828-9, 1836. Sylhet & Cāchār, 1837-43; Hd.mr. Sylhet Govt. Sch., 1843-5; N. Bengal Rev. Svy., 1846-7; in ch. Noakhall, 1847-8; Lower Assam, 1848 till ret. on pension, March, 1854.	m., Calcutta, 5-10-27, Harriet Elviras Benjamin; 2nd., Eleanor, before, 1841.
KIRPA RAM	1846	Ch. Ngpr. 1861-2.	
LALLA RAM b. *c.* 1820	1835	N. Bengal, 1863.	
LANE, Wm. [IV, 399]	10-2-37	*v.* Biographical Notes.	
LAWRENCE, John Hickson	...	*mutsuddi*, Bihār, 1846 Punjab, 1847-51.	
LENNOX, J. H.	...	Punjab, 1851-2.	
LITTLE, Edwin G. b., 10-10-45.	1-1-60	NWP., 1860-2; CP., 1870; NWP. 1872; ch. No. 7 Party, Burma, 1877-85; ret. 11-4-1901, after 6 mo. extension.	
LITTLEWOOD, Henry Ross b., 5-11-43 d., Mandalay, 9-8-94, cholera.	6-10-60	Assam & Bengal LP., 1860-70; CP. 1871; Orissa 1878; Burma 1879 served till after, 1884.	g. son of Rev. Samuel L., rector of Edington, Wilts; ed. La Martinière Sch., Calcutta; m. twice; 4 sons at Stoke's Sch. Masri., 1881-98, 2 following in Svy.

Name, Birth, Death	Appointed	Employment	Domestic
LOFTIE, Edw. b., Oct. 1827.	1-1-47	Punjab, 1847-55; Sind, 1855-70; Punjab, to 1877.	nat. son of Lt Col. Malcolm Edw. L. (1808-59), Ben. Inf.
MACONOCHIE, G. B.	1855	Bjptna, 1856, till resd. 1857 for civ. employ under Collr., Agra.	
MADGE, W. A.	1-12-59	E. Bengal & Arakan, 1859-60.	
MASSONI, Louis J. d., Serampore, 15-6-45.	14-11-36	Mdnpr, & Hooghly, 1837 till death.	
MAY, Robt. b. c., May 1830. arrd. India, 1832.	1-1-48	N. Bengal LP., 1848-50; absent, 1850-1; re-appd., 19-5-51; again absent sick from March 1852. Punjab, 1855 till absconded Sept. 1859.	father in Calcutta, 1849.
MCKEVER, J. P.	...		
MEANY, H.	29-9-57	Derajāt, 1857-60; Oudh, 1860 till resd., 1-10-60; re-appd., Oudh, 8-10-62; disch. from CP., 7-12-64.	from Lawrence Asylum, Sanāwar.
MILLARD, Sergt. Henry b. St. Martins in Fd., London, 1820/1. kd. by mutineers, Jhānsi, 8-6-57.	16-9-47	Canal Dept. Sind, 1845-7; Rev. Svy. Rhlkd, 1847-54; Bdlkd., 1854 till death.	enl. Ben. Eur. 11-6-39, London; arrd. India 11-11-39 wife & 8 ch. perished with him.
MONTGOMERY, C. A.	16-6-54	CP., 1854-7.	
MORAN, John Kenneth b. c., May 1835	1-7-51	E. & N. Bengal, 1851-4; with expn. to Kuki Hills, 1860-2; absent wl. to Eur. Jan., 1862.	
MULLINS, Chas. [IV, 399] b., 1809/10 bapt., Calcutta, 16-6-11.	1-11-33	Bengal LP., 1834-40; Bihār & N. Bengal, 1840 till pension 27-10-57.	son of Chas. and pr. cons. to Chas. Wm. (*inf*); m., between May 1849 and May 1850.
MULLINS, Chas. Wm. [IV, 400]	Nov. 1834	Bengal LP., till resd., 1840, for Salt Dept.; Survr. in Sundarbans, 1844 till pension 1852; then Customs, Calcutta.	m. 2nd. 1st., Chtgg., 29-11-38 Margaret Brown; 2nd., Calcutta., 8-1-41, Elizabeth Kerr; 3rd Calcutta, 20-10-43, Primrose Sheppard sis-in-law of Francis Moran [IV, 284].
MUNROW, kd. by mutineers, Jhānsi.	1853	Bdlkd., 1854 till death 8-6-57.	
NASH, G. E.	1-1-60	Manbhum, 1860-2.	
NICHOLSON, Thos. W.	1-12-59	E. Bengal & Arakan, 1859-62; Bengal LP., 1862-4; CP., 1864 till ret. 1-3-66.	
O'DONEL, James Hugh [IV, 400] b., 1819/20 d. in fd. nr. Nowgong, Assam, 22-4-72.	1-12-36	Orissa, 1837-40; Mdnpr, Purnea, and N. Bengal, 1840-53; ch. L. Assam, 1853-5; ch. Arakan & Chtgg. Hills, 1855-64; Assam 1867 till death.	m., Bglpr., 11-7-44, Charlotte, dau. of Geo. Buckland; their son, Jas. Boppner, appd. Rev. Svy., Oct. 1863.
OTTO, Geo. A. [IV, 400] b., 1826/7 d., Calcutta, 17-6-48.	18-3-41	Bengal LP., 1841 till death.	from La Martinière Sch. Calcutta.
PALFREYMAN kd., by mutineers, Jhānsi.	1856	appce., Bdlkd., 1856 till death 8-6-57.	
PARKER, John A. [IV, 400] b., 20-10-04 d. Bglpr., 15-12-53.	Sept. 1819	Bengal, LP., 1819, till dism., Dec. 1840; re-appd. Bihār, 3-10-44, till death. dmn., "of high order".	son of Wm.; m., Agra, 12-9-31, Catherine Manuel.
PATTERSON, Wm. Henry b., 24-9-38	1-12-51	Punjab & NWF., 1851-9; Oudh, 1859-62; Calcutta DO., 1862-6; Oudh, 1866-70; L. Assam, 1871-9; ch. Topo., Malwa, 1883-5; leave to Eur. 1862; 1872-3 1879-80; ret., aged 55, 24-9-93.	m., before, 1866.
PEMBERTON, H. L.	20-12-56	Bdlkd. & CP., 1856-66; "walking in the steps of his excellent father".	son of James Jeremiah [IV 460].
PEMBERTON, James Jeremiah [IV, 460].	1-6-35	v. Biographical Notes.	
PEMBERTON, Jas. Stewart b., 8-7-43.	6-10-60	CP., 1860-71; Punjab, 1872-78; Burma, Bengal, LP. till 1890; then ch. Punjab & Bihār parties, till ret. 1-10-98.	bro. to H. L. (*sup*).
PERKINS, J.	...	Punjab, 1852-3.	
PERMIER, Thos. Hanbury [IV, 398]	Feb. 1835	NWP., Bihār & N. Bengal, 1835 till resd., 1845; re-appd., 1846, Punjab till leave to Australia, 1852; possibly with Record-kpr, NWP. Sectt., Agra, 1855.	son of Asst. Commy. J. C. P., (1773-1841); m. Mary before 1844.
PHILLIPS, Anthony [IV, 400] b. c., May 1824.	Oct. 1841	Bihār, 1841-5; re-appd., 24-Parg., 18-49-52; Mimsg., 1852-5; Arakan, 1855 till ret., 1858.	son of Robt. Howell P.; m., Calcutta, 5-5-51, Delphine, dau. of Patrick Dudrence.
PHILLIPS, S. [IV, 400]	Oct. 1837	Balasore, 1837 till disch., 1842; with Rev. Bd., 1843-5 on Assam maps [242]; Lower Assam, 1845-52; E. Bengal, 1852 till resd. 25-9-56.	bro. to Anthony (*sup*); m. before 1855.
PICKARD, James b., 1831-2.	1-11-46	Bihār & LP., 1846-55; Arakan & Chtgg. Hills, 1855-64; N. Bengal & Ch. Ngpr, 1864-8; Assam 1867-9; Burma 1869.	son of Henry; m., Calcutta 18-11-56, Esther Eliza, dau. of Thos. White.
PICKEL, Henry b., America, 1822/3; arrd. India, 1845.	1-10-45	Tirhut & E. Bengal, 1845-50; Punjab, 1850-1.	
PORTEOUS, H. A. [IV, 400]	Oct. 1836	Chtgg., Bihār, Mdnpr., 1836 till disch., 1842; Arakan, 1853 till sick leave to England, 1855; resd. on return, 1-9-57.	H. A. P., of Customs, d., Calcutta, 9-7-59.
PRINGLE, John Robt. [IV, 400] b., 1819/20 (1812-3 ?)	1-3-38	Orissa, 1838-42; N. Bengal, 1843-65; Assam, 1865 till ret. 1867/8, aged 55.	son of Robt. P.; m., 1st., Kdrpr., 27-11-49, Hannah Amelia, dau. of Wm. Thorpe; 2nd., before 1872, Christina Madeline.
PRINGLE, Walter Hovenden [IV, 400] b. c., 1822	1841	Orissa, 1841 till disch., 1843; ch. foundry, Calcutta, 1843 till re-appd., 1-11-46; Bengal, LP., 1846-53; ch. Arakan, 8-11-53 till dism., 1856.	bro. to J. R. P. (*sup*); w. and 3 ch., to Arakan, 1853.
RAE, Geo.	1-9-59	CP., 1859-77; Bihār, 1877.	
REJONIER, E.	5-12-55	Arakan, 1856 till absent from Aug., 1857.	from Montague's Sch., Calcutta.
REILLY, Thos. Wilfrid b. 1842	18-10-59	Bndlkd. & Oudh, 1859-61; Calcutta DO., 1865; CP., 1865-71; Bo. Deccan topo. 1872; Calcutta DO. 1876-7.	
REYNOLDS, W. H. b. 20-2-43.	14-3-61	Punjab & Derajāt, 1861; Asst. Survr. Amberyla expn. 1863; resd. 18-7-70 to Forest Dept.; Conservr. 1887; to S. of I. 24-10-90; Supt. Forest Svys till 30-9-99.	from Lawrence Asylum, Sanāwar; FRGS.

Name, Birth, Death	Appointed	Employment	Domestic
ROSSE, John James [III, 372; IV, 398].	23-7-23	NWP., 2823-41; Bihār, 1841 till disch., 16-12-44.	son of Lt. Qmr. of HM. 8th Dragoons.
SANDERSON, W. b., England.	Oct. 1847	from Ordnance Svy. GB.; Rhlkd., 1847 till disch., 1851, "a troublesome character"; to Supt., Embkmts.	
SAVAGE, R.	Aug. 1857	Arakan & Chtgg. Hills, 1857 till resd. 16-8-65.	from Montague's Sch., Calcutta.
SCOTT, R.	1-10-51	Punjab, 1851-9; Ch. Ngpr, 1859-62.	
SHERIDAN, C.	20-9-60	Oudh, 1860 till resd., 1-11-64.	
SINCLAIR, Wm. b. Sept. 1838.	1-1-54	Manbhum & L. Assam 1862-9; CP., Ch. Ngpr & NWP, 1870-6 furl. to England, 1876-7; DO. Calcutta, 1878-93; ret. 23-9-83.	m., Dora Elizabeth before 1871.
SMART, Arthur David b. 15-10-30.	3-12-47	Bihār & Bengal LP., 1847-62; Upper Assam 1862 till resd., 5-1-65; to hp. list 1-10-70, to ch. training party; to suptd. Mhrja. Ch. Ngpr. Estates till ret. 15-10-55 aged 55.	bro. to Robt. (*inf*), as widr., m., Calcutta, 2-11-59, Julia Piele, dau. of B.W. Lazarus.
SMART, Robt. Broughton b. c., 3-3-27.	21-9-46	Bihār & Bengal LP., 1845-60; ch. N. Bengal, 6-10-60, & Assam, to 1865; ch, CP., No. 2, 1866-72; Bdlkd., 1872-6; Orissa, 1876-80; furl. to England, 1880 till ret. age 55, 1812.	as widr., m., Calcutta, 25-10-59, Harriet Jane, wid. of G.R. Wilby; father of Robt. Boddington, appd. Rev. Svy. 1-1-64; member ASB.
SMITH, Anthony [IV 400] b., 1819/20; dro. 31-3-50 Burral R., Rājshāhi.	16-1-37	Sylhet, 1837-42; N. Bengal, 1844 till death.	
SMITH, Henry Maitland [IV, 400] b., 1813/4 d., Akyab Dist., 12-4-59.	June 1835	Med. Dept., 1829-35; NWP., 1835-8; Orissa, 1838 to disch., 1842; St Nvgn. Dept., 1843-50 as engr. str. *Jumna*; re-appd., L. Assam, Oct. 1850-4; Bengal LP., 1854-8; Arakan, 1859 to death.	
SMITH, Robt. Abraham [IV, 400] b. c., Dec. 1825.	1-2-41	Purnea & N. Bengal, 1841 till temp. ch. 19-3 to 6-10-60; absent wl. 16-11-60.	
SMYLIE, Samuel Mack b., 25-11-40.	24-7-60	E. Bengal, 1860-7 Kyaukphyu, Burma, 1868-70; N. Bengal 1870-2 Deccan topo. 1872-80; Calcutta DO., 1883; Hd. dmn., from 1888; CD., 1892 till furl. 1-4-94 pendg. ret.	from Serampore Coll.
STERNDALE, Wm. Crawford b., England, 1831/2.	7-5-49 Calcutta	24-Parg., resd., 28-6-49; after one month's service.	
ST. GEORGE, Wm. b. 1826/7	July 1852	rev. svy. Rhlkd., 1852, till resd., June 1855, to Rlwys., Shāhjahānpur [437].	from 14th Lt. Dragoons'.
STEVENS, Henry W. b. & ed., England arrd. India, 1856.	4-12-56	from Bengal Mar.; E. Bengal, 1856 till resd., 4-12-59, on completion 3 y., service.	bro. to Wm. (*inf*).
STEVENS, Wm. b. & ed. England arrd. India, 1856.	20-5-56	E. Bengal, 1856 till absconded, 15-10-58.	bro. to Henry (*sup*).
SULLIVAN, P.	1849	24-Parg., 1849 till resd., Feb. 1850, to join parents.	son of Ordnance Sgt., Dum Dum, tr., 1856 to Agra.
SWETENHAM, E.	1854	Rjptna, 1854-5; CP., 1855-6.	
SWINEY, Geo. S. [IV, 400] b., 1822/4	Oct. 1841	Cchr, 1841 till disch., 1842; Asst. mr., Govt. Sch., Sylhet, 1843-5; re-appd., Mdnpr, 1855-6; Bihār, 1846 till suspended, 1848-50; E. Bengal, 1850-65; Kyaukpyn, Burma, 1869-71; out of lists from 1877.	bro. to John (*inf*); m. before 1850.
SWINEY, John [IV, 400] d. Assam, Jul-Aug. 1848.	17-1-37	Sylhet & Cchr, 1837-43; Mdnpr, 1844-Sept., 1847; Lower Assam, Nov. 1847 to death.	bro. to Geo. (*sup*).
TALBOT, Henry Blaquière b., Oct. 1830.	1-12-48 GTS., 1-10-52; Rev. Svy.	resd. from topo. 1-7-62 [432], to Rev.; Punjab, Bdlkd. & CP., 1852-61; ch. Rhlkd., 1862-5; Upper Assam, 1865-72; NWP., Bihār, Orissa, 1872-80; Burma, 1880 till ret., Oct. 1885 at age of 55.	Father ill at Lucknow, 1851; m., Rebecca before 1862.
THOMPSON, Corrie	10-1-59	Oudh, 1859 till resd. 27-6-60; with forfeit of ½ salary.	
THOMPSON, Geo. V. b., 1830/1.	19-11-47	Bihār, 1847-8; Bengal LP., 1848-53; L. Assam, 1853-4; Arakan. & Chtgg., Hills 1855 till resd. 27-12-65.	
THORNTON, J. L.	...	Punjab, 1853-5.	
TODD, James	1-12-5	Roorkee Coll., 1850-2; dmn. with CE., Lahore, 1852-5; Sind Rev. Svy., 1856 till resd. 1860, "heavily in debt."; re-appd., Oudh, 27-12-63; Ch., Ngpr. 1864-70; Mdnpr, 1872-8.	m. Margaret R.
VAUGHAN, James	30-12-54	CP., 1854-6; ch. Orkpr. dett., 1856-7; Bengal LP., 1858 till resd. 15-9-60, for appt. Dep. Collr., NWP.	
VYALL, Wm. Robt. b., c., 1838/9 d., Rangoon, 28-8-88.	13-6-56	Roorkee Coll., 1854-6; CP. & Oudh, 1856-64; Chtgg. Hills, Ch. Ngpr, N. Bengal, & Assam 1864-75; Orissa, 1876-83; furl. to England, 1883-5; Burma, 1886 till death.	
WALLACE	...	Rhlkd., 1849-51.	
WALSH, H. d., 24-4-68. cholera	14-3-61 Bijni, Assam	Derajāt, 1861; Oudh, 1862-4; Arakan, & Chtgg & Assam 1865 till death.	from Lawrence Asylum, Sanāwar.
WARD, W.	1-12-58	Bdlkd. & CP., 1858, till resd., 1-11-61.	
WATSON, Thos. Edw. [IV, 400] d., Calcutta, 18-11-47.	1-11-38	Bengal LP., 1838 till death.	his father d., Calcutta, 1844/5.
WILLIS, Richd. b., England, 1828/9 arrd. India, 1845/6.	1-9-47	24-Parg., 1847-8; N. Bengal, 1848-9.	
WILSON, Wm. A., senr. [III, 372; IV, 375] b. c., 1806.	4-12-23	Upper Provs., 1823-30; Calcutta DO., 1830-4; Bihār, 1834-8; Orissa, & Tippera, 1839-44; Bengal LP., in ch., 1844 till dism., 1848; re-appd., CP., 1856 Oudh, 1860 till ret 4-1-63.	ed. Upper Mil. Orphan Sch., Kdrpr.; m., Calcutta, 1833; 2nd., Calcutta, 21-8-42, Mrs. Margt. Mitchell; father of Wm. Alex. (*inf*).

[1] enl., London, 9-1-49; emb. 15-6; arrd. Calcutta 28-9-49; joined regt. Lahore; marched Meerut Feb. 1851 purch. disch. as pte., 5-7-52 for £30; PRO; WO. Muster Rolls 12/12754/11658.

Name, Birth, Death	Appointed	Employment	Domestic
WILSON, Wm. Alex., junr.	1-1-61	Oudh, 1861–4; Bengal Lr., & Assam, 1864–71; Bhlkd. & Bwlpr. 1871; Bengal 1876; to gaz. rank, 1892	son of Wm. senr. (*sup*).
WRIGHT, T. B.	...	1864–5.	
WYATT, Alex. [III, 366, 372; IV, 398]	26-12-22	v. Biographical Notes.	
YOUNG, G. kd., by mutineers, Jhānsi, 8-6-57.	1856	appce., Bndlkd., 1856 till death.	
YOUNG, J. kd., by mutineers, Jhānsi, 8-6-57.	...	Bdlkd., 1856–7.	pr. bro. to G. Y. (*sup*); wife perished with him.
YOUNG, Robt. James b., 20-2-20.	30-11-54	Rjptna, 1854, till joined Jhind Art., before Delhi, 1857; appd. PWF., Police, Nov., 1858.	m., Masri., 26-6-58, Ellen, dau. of David Ferrier.

NOMINAL ROLLS: BOMBAY & BERĀR

Revenue Surveyors Bombay and Madras were not under orders of Surveyor General

ABRAHAM, W. — dmn. Sind, 1850; Auth of *Lithography in India*, pub. 1864 when in ch. Litho. Dept., Bo. Edn. Soc. Press.

ALLSOP, T. — appd., Deccan, 15-6-42, from Sgt., Bo. S & M.

BAKER, Alfred — SMC., 1850; Amdngr., 1851; Khāndesh, 1858–60; wife, Mary Wykham, d. 1865–6, at Warsar, Khāndesh.

BAKER, Arthur b. Calcutta, 29-9-31 d., Bombay, 26-8-62; — Amdngr., 1851, Asst. Supt; 12 mo. leave mc., to England, 27-10-59; Gujarāt, 1858–9; Asst. Supt. at death. MI., Colaba.

BELL, Wm. H. [IV, 368] — Deccan, 1837–49; SMC., 1850; Amdngr., 1851; pensioner, Poona, 1858.

BEYNON, Robt. Cathcart — arrd. India 1854; SMC., 16-10-57 to 1870; memo. on S. Div. Rev. Svy., *IO Cat.* (421) furl mc. 1867–8 & 1879–82.

BEYNON, R. R. b., 27-10-39. — appd. Asst. Supt., SMC. 12-10-59; Berār, 1868; Supt. 1877 @ Rs. 1,400

BEYNON, W. H. — Deccan, Asst. Supt., Poona, 1847.

BEYTS, N. B. — appd., Gujarāt, 14-10-54; Dep. Supt. 14-12-65; Supt. 1876; furl. mc. 1871–3 & 1880–1.

BRABAZON, Sgt. W. — Sind, Asst. Survr., 1850, on minor trgn.

BUDWELL, Thos. — Deccan, 1853.

BULKLEY, Alex. S. — appd., Gujarāt, 16-11-55; serving till after 1876; son b. at Surat, 22-4-59.

BULKLEY, H. — Gujarāt, 1858–60.

CLARK, Thos. — Deccan, 1846.

COLEBROOKE, — Deccan, from Corpl., PWD.

COLEMAN, H. — SMC., 1858–60; wife Mary, d., Belgaum, 17-7-59.

CRITCHELL, Edw. Richd. b., 1819/21 d. Surat, 10-9-71. — appd., Deccan, 26-6-38; Sind, 1850; Gujarāt, 1854–60; "can survey well on circuit system" out of list 1877; m., Poona, 15-9-43, Mary Anne Harriet, dau. of Fredk M. Beck; g.father of Martin Critchell, S. of I., 1910–50.

CUMMING, M. Anthony — appd. 17-11-52 Khāndesh, 1858–60; Amdngr. 1869–70; m., Juliana Ruth, who d., 8-7-81, aged 49; MI. Wanouri, Poona.

DAVIDSON, A. Fletcher b., Haddington, Scotland, 1822/3. — Amdngr., 1845–7; Nāsik & SMC., 1849–51; Amdngr., 1851, Supt. Khāndesh, 1860; out of list 1870; widr., bro. to Maj. David D. [1811–1900] [IV, 429].

DE SOUZA, Francis — appd., Gujarāt, 6-12-55; Ratnagiri, 1883.

DISNEY, Harold King — arrd. India, Tel. Dept. 1857; appd., Khāndesh 27-3-60; still serving, 1883. furl. mc. 1864–5; 1873–4; Berār 1866; Thāna & Ratgri.; 1869; Poona & Nāsik; CP. 1874.

DOWMAN, J. — appd. Sind, 16-1-60; serving 1870; pr. kin. to Henry appd. Orissa Rev. Svy. 16-10-62.

DRAGUP, Wm. — Hd. Clerk, SMC. Rev. Svy. 1853; pr. m. Johanna; their twin sons d., Sept. 1846, at Hdhd., Sind; MI., Wanourie, Poona.

EDGE, James — Bombay Port; with Collr., 1842; with Rev. Dept., 1846, still serving, 1853.

GILDER, J. C. — Berār, 1858–60.

GOODDINE, Robt. Henry Newton d., Poona, 18-9-55, [IV, 397] — Nāsik, from Mil. Sub-Condr. appd., 28-10-43 [IV, 397]; Amdngr., 1850–1.

GRAY, W. — Khāndesh, 1858–60.

GRANT, H. M. d. 2-8-77. — appd. Thāna & Ratgri. 19-10-59; Amdngr, 1863; actg. Supt. Thana & Ratgri, 1870.

GUERIN, J. A. b., 27-6-37. — appd. Asst. Supt., Gujarāt, 4-11-56 1864–5; Berār, 1869, still serving, 1873, but out of list, 1877.

HALL, J. C. — appd. Asst. Supt., Gujarāt, 1858–60, Thāna & Ratgri., 1868; Gujarāt 1870; out of list 1877.

HARRISON, Walter Geo. — appd., Thana & Ratgri, 25-6-56; Thāna, 1860; N. Division, 1870; Ratgri, 1872; furl. 1875–6; 1882–4; Santavadi & Ratgri 1876–82.

HATHWAY, W. H. — Khāndesh, 1858–9, Poona & Thāna, 1860.

HEARN, Edw. Henry — appd., Deccan, 25-9-55; Thāna & Ratgri, 1864–70; N. Div., 1870; Ratgri 1876, furl., 1856–7; 1875–7; Santdl, 1873; 1881–3.

HEXTON, Sgt. Chas. [IV, 397] b., Lancs. England, 1816/7. arrd. India, 1836. — PWD., 1836; BO. S & M, 1840; rev. svy. Nāsik, 1843; Poona, 1849; Thāna, 1852; Hon. Lieut. 1865; Rtgri. 1867; furl. 1871–3; resd. 1873 for uncov. civ. service, 1873–6.

HOBSON, E. A. b., 30-10-35. — appd. SMC., 25-6-56; SMC. 1860; Berār, 1868; bdy. Settmt. Offr., 1872–3; furl. 1869–70.

HUGHES, A. W. — Poona & Thāna, 1858–60.

JERRARD, Condr. H. — Khāndesh, 1858–60.

JOHNSON, G. W. — Sind, 1860.

JONES, Sgt. W. — Sind, 1849–50; Asst. Survr., "good observer with theodolite".

JORDAN, J. — Ahmedābād, 1847.

JORDAN, Alex. Henry — Gujarāt, 1858–60; son of Thos., Dep. Collr., Amdbd; d., 25-7-65, aged 27 y. 21 d.; MI Wanauri, Poona.

JORDAN, Thos. S. S. — Ahmedābād, with Collr., 1847.

KELLY, Wm. Michael [IV, 240] — Surat, with Collr., 1842, "Survr. & Builder", also 1853. His wid. Anna Maria d., 25-6-84 aged 86; MI., Mari.

LEAVY, T. — Deccan, 1842–6.

LIGHT, R. E. H. — appd. SMC., Asst. Supt., 21-3-51; Mysore, 1865; Supt. Photo-zinco, Poona, 1870–76; SMC. 1877 son born at Dhārwār, 30-8-59.

MITCHELL, James — Deccan, 1847–8; SMC., 1851–3.

MORRIS, F. — Gujarāt, 1860.

NEPEAN, C. E. F. — Gujarāt, 1858–60.

PARKINSON, H. H. S. — Gujarāt, 1860–65.

PEELER, Sgt. — Sind, 1850, "a beginner".

PITT, Robt Bulkley
b., 31-12-38.
appd. Asst. Supt., Khāndesh, 12-10-59; Berār, 1864–8; Asst. Sett. Offr., 1868–70 Poona, Thāna, Nāsik, 1873–7; 1877, furl. to England; still serving 1883.

PRICE, P. (or W.?)
Deccan, Asst. Supt., 20–11–44.

PRICE, Wm. Samuel, senr.
[III, 386; IV, 386]
b. Bombay, 1811/2.
Deccan topo. appd., 1–5–26; trgn., 1828–35; rev. svy. SMC., 1850–9; Satara, 1860.

PRICE, Wm. Samuel, junr.
appd., SMC., 2–7–56; actg. Dep. Supt. 1870; still serving, 1877; son of Wm. Samuel, senr. [*sup*].

RAE, Henry Daly
d., Ootacamund, 6-12-66.
Gujarāt, 1858–9 12 m., leave to Nilgiri Hills, 17–9–59, d., aged 35; MI.

ROWELL, H. G.
Khāndesh, 1858–60.

STEVENSON, T. S.
Poona & Thāna, 1858–60.

SCOTT, James Wm.
appd., Khāndesh, 25–6–56; Amdngr, 1868–70; Poona & Nāsik, 1870; still serving 1883.

SPRINGER, John Hans
[III 386; IV, 386].
Deccan topo., 1823–34; rev., 1837–45; SMC., till death; b., 1809/10; d., Poona, 20–2–61. MI.; wid., Joanna, d., 1882.

SPRINGER, W.
SMC., 1847–50.

SUMMERS, Hector Hamilton
appd. Asst. Supt., Gujarāt, 27–9–54; 1858–60; Ratgri., 1881–3.

WHITECOMBE, John Cornelius
Clerk, Mil. Bd. 1847–57; appd. SAS. Khāndesh, 8–4–57; Poona & Nasik 1871, furl. 1882–3; Poona, 1883.

WILKINS, W.
appd. Sind, 15–2–57; serving 1870.

YOUNG, David
b., Scotland, 1822/3.
appd. Asst. Supt., SMC., from sub-asst., 10–9–44; wife, Ellen, b., Bombay *c.*, 1833/4.

MADRAS: CIVIL SURVEYORS & ASSISTANTS

BEAUMONT, W.
appd., Trichl, 21–5–58; Wynaad, 1860; furl. 1860–1; 1867–8; 1876–7; Nellore, 1863–4 Dep. Supt., 1870–7.

CARDOZO, Henry O'Connell
v. Biographical Notes.

COOKE, J. P.
Mad. Town svy. 1857–62; *IO Cat.* (356).

DUNSFORD, H. C.
1859; Guntur, 1863–4.

GOMPERTZ, Henry J. C.
appd., Trichl., 12–8–59; Kurnool; 1863–4; Godāvari Asst. Supt., 1870; Dep. Supt., Madura, 1877; ret. to Bedford, England; father to H. W. Gompertz, Mad. Cav. & Frank Vincent, G. Supt. Mad. Rev. Svy.

LEGGATT, B. C.
appd. Trichl., 8–9–59; asst. Supt. 1860; Dep. Supt. Nellore, 1862–3; not in 1870 list.

PLUMBE, M. G.
Madras Town, 1857–62, *IO Cat.* (356).

PUCKLE, F. C., M.A.
appd., Trichl. 19–3–58; Nellore 1863; furl. to Eur. 1864–5; 1869–71; 1879–80; 1870, Dep. Supt., Cuddapah. actg. Supt. Rev. Svy. 1878 & 1880 Tinnevelly.

PUCKLE, B. W.
Nellore & Salem, 1863–4.

SCOTT, R. L.
wife Eliza d., Kurnool, 22–7–65.

TOMLINSON, James, J.
appd. 22–3–60; Guntur, 1863–4; resd. 1864; reappd. 1865; Madura from 1878.

TOMLINSON, T. A.
appd., 12–8–59; Kurnool, 1863–4; Cuddapah, Asst. Supt., 1870; Madura, 1877; furl. 1879–81.

WALKER, W. H.
Madras Town, 1854–9. *IO Cat.* (356).

WEIGHT, J. H.
appd., 21–5–58; Madras, Asst. Supt., 1870; Bellary & Cuddapah, 1877.

WYLIE, James Thos. Harris
asst. Rev. Survr.; d., Madras, 10–5–54. MI. St. Mary's cem.

CHAPTER XXVIII

INDIAN STAFF

SURVEYORS: *G.T.S. — Topographical Parties — Early Explorers — A Bombay Experiment — Revenue Surveys: Bengal* — KHALĀSIS & LASCARS: *G.T.S. — Topographical Parties — Revenue Surveys.*

FROM the earliest days Indian writers and draughtsmen had been employed for office duties [IV, 335–7, 404; V, 360] and Indian land-measurers for revenue surveys [III, 388–93]. After 1830 Everest found that Bengali students made excellent computers and the computing office continued at Calcutta till 1862 [IV, 337–43; V, 354–6, 360]. For the field work of the Great Trigonometrical Survey, however, Radanath Sickdhar was the only success [IV, 401, 461–2].

At the end of 1856 the Surveyor General suggested that, in line with topographical parties, two or three Indians might be engaged on the Great Indus Series, and Walker agreed that there were various duties such as secondary triangulation which they could perform quite as well as Europeans;

> There will be a great saving of expense. ... I would suggest Rs. 30 a month as the minimum on entrance, to be increased to Rs. 50 as soon as the surveyor can pass a good examination in plane trigonometry and can observe well with a 7″ theodolite. .. In the levelling operations I think they could render good service, working under an officer or a sub-assistant[1].

Three men recruited from the Lahore School of Civil Engineering in 1857 showed little interest in the work; they were distracted by the prevailing disturbances, and were discharged after two or three months. A fourth, from Peshāwar, was more promising, but became involved in subversive intrigue, and was also discharged[2]. Walker then engaged three men for levelling, one of whom, Ram Chand from Lahore, had been with Adolf Schlagintweit and proved a most valuable leveller. His death, after a fall from his horse after nearly nine years service, was a great loss to the Department[3]. The other two were never more than recorders [77, 79].

TOPOGRAPHICAL PARTIES

Owing to the difficulty of finding Europeans and Anglo-Indians for the topographical parties, start was made about 1854 to recruit Indians. Robinson asked for

> the additional assistance of two superior, well educated, natives, speaking and writing English fluently, understanding arithmetic and the first rudiments of algebra and geometry, ... and if possible possessing some skill in drawing. ...
>
> One sub-assistant is required to be in advance of the triangulation, selecting and placing poles...for the planetable surveyors, and laying down on a planetable a skeleton chart of all the stations and poles so prepared. ... I propose...to employ one native surveyor on this duty. ... With very little training a native will soon learn to perform these duties as well as an European, ... and...will...soon learn to fill in topographical details with the planetable. ...
>
> Another European sub-assistant has hither to been employed as office and observatory assistant. A native surveyor could efficiently perform these duties, viz., recording, making duplicates of angle-books, and...assisting in...computations...in the field. ...
>
> In the recess these native surveyors would be...making duplicate angle-books, ... preparing annual returns and comparing duplicates, and...assist in computing. This would allow of the whole of the European establishment being employed in mapping and computing[4].

[1] DDn. 722 (395), JTW. to SG., 4–12–56. [2] DDn. 710 (187), JTW. to SG., 30–11–57. [3] d. 19–1–67; family gratuity; DDn. 93 (283), STS. to Home Dept., 20–5–67. [4] DDn. 731 (7), DGR. to SG., 10–5–54.

On this suggestion the Surveyor General obtained sanction for the appointment of "native surveyors", two each at maximum salary of Rs. 70 for the Punjab and the two Ganjam parties, and six for the Hyderābād party on Rs. 40 to 60.

The introduction of the native surveyors...is experimental. They have not, it is believed, the same coup d'oeil and power of drawing from nature that Europeans have. The competition of other departments, however, makes me disposed to...give a further trial to native agency. If it succeeds it will tend to economy; ... the native surveyors as draftsmen will relieve the field sketchers from office duties, which will enable them to execute more field work[1].

Robinson was at first doubtful about their employment on planetabling;

The system of the revenue survey supplies many good checks, but I do not see what checks you can establish over a planetable surveyor other than an accurate and careful comparison of his work with the ground after he has completed it. This examination would occupy much time and labour and...might be too expensive [IV, 258][2].

The Surveyor General discounted these fears; check was essential;

In the evidence before Parliament on the Ordnance Survey [253] the opinion...is recorded that there is no test for the accuracy of land-surveying short of an equally good resurvey. ...

The trustworthiness of a native planetable surveyor may be fully checked, 1st.—by satisfying oneself of his competence and knowledge. ... 2nd.—by testing his rate of progress according to character of ground. ... 3rd.—One or more portions of his season's work taken at random should be revised. This is a partial test, ... logically imperfect, but if judiciously, strictly, and faithfully applied...is morally sufficient[3].

He passed these views to Mulheran [416], adding that from his own experience untrustworthiness is generally the consequence of ignorance, bad training, and inability. Men generally do things well and thoroughly for which they have a real aptitude. ... Nevertheless vigilant inspection after due training is also incumbent, and on these two principles, viz., adequate training and vigilant inspection, success depends[4] [290].

Robinson's most successful find was Abdul Sammad Khan, recruited from 1st August 1857 after previous service with the postal and settlement departments. During season 1858-9, he planetabled 140 square miles of easy ground, and in 1860 with Kalka Prasad and Akbar Khan he accompanied the party to Central India and did good service till his death about 1874 [190].

During 1856–7 Mulheran engaged Bapa Rao, Panda Rao, and Ramchandar Bapooji, all Marāthas, for the Hyderābād survey [178–9, 485] and at the same time Abdul Rahman and Ghanosam Banerji joined the parties in Orissa [172]. Banerji did good work till he resigned in October 1863 for other employment, whilst Abdul Rahman's death in 1865 was "a serious blow ... I have seen him on the top of a hill with his planetable...when the active stage of a fever was on him"[5]. Saxton lost another useful surveyor in 1866, Hidayat Ullah Khan.

On the Pegu survey [196–7] a number of Burmese and Karens were taught traverse survey, some from mission schools, others, with Indians, from the Public Works Department [425]. On winding up the survey in 1867 Edgecome reported Maung Pho as "a capital fellow—wants to return to the P.W.D.—the best Burman I ever met". He could not recommend Samuel Peter from upper India, with 8 years previous service as clerk and one with the Pegu Survey, but Gour Chandra and Ram Lusan—"efficient, trustworthy, and hard working" but only acquainted with traverse survey—were transferred to No. 6 Topo. Party in the Khāsi Hills.

EARLY EXPLORERS

Between 1850 and 1853 on his survey of Peshāwar Walker employed two Persians, Mirza Sujah, or Sajjad[6], and Mirza Abdullah [47, 215]. He employed the latter in the direction of Buner;

Having long resided in Peshawur, and being familiar with the language of the country, there was little chance of his mission being suspected. Ascending the Surputta Peak west of

[1] DDn. 549 (143), SG. to Mil. Dept., 10-9-55; sanctioned BMC., 29-11-55; DDn. 548 (105) & 656 (44), 19-56. [2] DDn. 731 (2), 15-10-56. [3] DDn. 691 (183), 23-10-56. [4] DDn. 656 (88), 28-10-56. [5] *GR Trig. & Topo, 1864-5*, Appx. (Ax). [6] Turk father, Persian mother; cf. *JRGS.* XLI (132).

the Mahaban, ... he was able to obtain...useful observations with a compass, the only instrument that could be taken without exciting suspicion; all the chief villages were determined[1].

Mirza Sajjad had a long connection with the Survey. He had first attracted the attention of Eldred Pottinger at Herāt in 1838 [IV, 461], and was taken by him to Kābul and taught English. After three years with Walker on the Peshāwar survey, he was employed on roads and other public work round Peshāwar and Pindi till he rejoined Walker at the end of 1855 on the Jogi Tila series. Walker found him useful and recommended his formal appointment to the G.T.S., though his mathematical attainments are not enough to enable him to take a share in the computations. '... He would probably be better placed in the Kashmir series, ... reconnoitring the countries beyond the boundary. He is...well-born and respectable and may seek information among Mussulman tribes who would not suffer the approach of Europeans[2].'

As Montgomerie had then no suitable work for him he was employed by Walker on the Great Indus Series; "he can observe with the new 7-inch theodolite, and can compute the general problems connected with triangles. He is very slow... but is careful and correct. As a draftsman he has not much skill[3]".

With a view to his future employment "with exploring expeditions" the Surveyor General asked that he should be taught to make all the observations ... such as observing for latitude, time, longitude, azimuth, ... magnetic deviation, base measurements, angles for heights and distances, barometrical heights, thermometrical heights, and climatic observations and recording them intelligibly. Even if unable to master all the computations and reductions, ... he might at any rate be able to assist a European explorer[4].

The Mirza remained with the Indus Series till October 1857, being employed on tower building and line cutting and being trained on the lines suggested, and was then granted six months leave "to go to Kābul to recover some money with which a merchant of Peshāwar has absconded"[5]. He wrote some months later saying that he could not return as he had entered the service of Dost Muhammad "whose children he is to instruct in the English language"[6].

Some years later he returned to India and sought re-employment. During 1868–70, he travelled through north Afghānistan and the Pamirs to Kashghar[7], and again in 1872–3 to Turkistan, where "he and his son-in-law...were both treacherously murdered by their guides during the night while they were asleep"[8].

Besides Ram Chand [76–80], the Schlagintweit brothers collected a number of enterprising assistants for various branches of their work, amongst them being Abdul, who had served under the Quartermaster General at Madras. Joining in February 1855, he explored several routes in Sikkim—made the boat journey along the Tista into Assam—and accompanied Adams up the Dihing River [145].

Three Bhotia relatives joined them from Johar Bhot in upper Kumaun—Mani, Dolpa, and Nain Singh. Mani Singh's father, Devi Singh, who had helped Moorcroft in 1812 and Strachey in 1846, was still alive [II, 431; V, 187]. Dolpa, "full of courage, energy, and devotion", was interpreter to Adolf. Nain Singh, cousin to Mani Singh, accompanied Hermann to Ladākh in 1856; "at first unacquainted with instruments, was soon taught their use. ... He could also read and write Tibetan". Nain Singh later became one of the best-known explorers of the Great Trigonometrical Survey, earning the titles of Chief Pandit and Companion of the Indian Empire. Mani Singh, the "Patwar or GM.", also joined at Dehra Dūn with Nain Singh in 1863 for training in exploration survey. He was the older, but not so active or bright as Nain Singh. His younger brother Kishen Singh, or AK., also made outstanding contributions to geographical knowledge beyond the mountains[9].

[1] DDn. 593 (543), to SG., 11-9-54 (para 22). [2] DDn. 642 (47), JTW. to SG., 9-5-56; BMC. 5-2-56; DDn. 551 (287); DDn. 709 (255), SG. to JTW., 25-9-56; *GTS. IV & Syn.* VI (xxiii—G). [3] DDn. 710 (160), JTW. to SG., 16-10-56. [4] DDn. 691 (212), SG. to JTW., 5-12-56. [5] DDn. 710 (179), JTW. to SG., 20-10-57. [6] ib. (203), 24-5-58; *RGS Progs.* XV (181-204); paper by TGM. 24-4-71. [7] *JRGS., XLI, 1870.* [8] *GTS. IV & Syn.* VI (xxiii—G); *GR. Trig. 1858-9* (viii); *1869-70.* (11-2; III-XCIV); 1872-3 (29); *Geo. Mag.* I, 1874 (35); Markham (155-6). [9] DDn. 8 (95), Maj. E. Smyth to SG., 25-10-62; Markham (149). The cryptic pseudonyms were devised from the final and initial letters of the English form of name; thus GM. came from MAN SING and AK. from KRISHNA (Kishen Singh). For detailed records of the work of these explorers v. *SI. Records* VIII, 1915; GTS. corr. DDn. 31-4; 441-2; 591-4, and SG. fd. corr., 1865-80.

It was largely on Montgomerie's initiative that this irregular body of trans-frontier explorers was recruited, trained, and sent out on individual missions. It was also Montgomerie who led the way in unravelling and compiling their field notes and observations, and working them into the general map[1].

A BOMBAY EXPERIMENT

In 1849 George Jervis, Chief Engineer at Bombay, pressed for topographical surveys of the Bombay Presidency, based on the trigonometrical survey [191–2];

I have prepared at my own expense...a class of 10 or 12 native youths who will...be fully equal, under the superintendence of two most intelligent and highly educated native engineers in my office, to execute...trigonometrical operations and fill in their topographical details.

These Superintendents and...youths have been thoroughly trained. .... They are of far more value than four times as many expensively paid young officers who think less of their public duties than of their private convenience and field sports. ... I have succeeded in raising a really intelligent and efficient race of beings to carry out the more irksome and laborious, but... scientific, details of surveying, ... for filling up the immense gaps of unsurveyed districts under this Presidency[2].

Waugh was sympathetic, but suggested a cautious beginning on a limited scale;

The Great Trigonometrical Survey of India contains men of all countries and creeds, and it was always the practice...to treat everyone without distinction [IV, 379; V, 380, 390]. There are good, bad, and indifferent men in...every rank of life. ... There are idle and wild officers as well as officers of great industry and business habits; so also I have met with natives of wonderful energy and talent, and others of the most inferior stamp.

In the Revenue Survey almost all the work is done by natives for the sake of economy [III, 388–90]. It answers well when quantity not quality is considered, and if a proper check be maintained, for these natives are paid very small wages, ... from Rs. 8 to 40 per month. ...

With regard to highly educated natives...with one exception [obviously Radhanath Sickdhar], I have found them generally wanting in energy for field work. ...

For filling in surveys good draughtsmanship is a sine-qua-non, and even more essential than mathematical knowledge. ... I suggest that a commencement should be made with a smaller party...because it will take some time to instruct novices, and the superintending officer himself will not be firmly seated in his saddle at first[3].

Determined to get work started before he left India, Jervis ignored Waugh's advice and obtained the appointment of a young engineer officer, Castle Boddam, for independent charge of ten of his Indian pupils, to work in a hilly area on the line of the Abu series [57, 191–2]. The experiment was doomed to failure. Boddam had no survey experience, and had first to carry out secondary triangulation to provide points for his untrained pupils. He had no time to look after them himself;

When I took them up to Guzerat in November 1850, they were perfect tyros at their work, for though they had learnt surveying theoretically they never had any practice in the field beyond once making a small survey of Malabar Hill. .... Many of these lads had hardly ever been out of the Island of Bombay; consequently when they had to march they were perfectly helpless. ... Observing that all travellers in Guzerat went armed, they imagined they had entered a land of freebooters and robbers. It was some time before I could prevail on these young surveyors to detach themselves from headquarters, and then only by supplying the khalasis...with belts and swords, and this I did from my own resources.

A few...now take an interest in their work, but others...long to return to Bombay. They declare that when volunteering for the survey...they had no idea they would be subjected to such hardships and discomforts. ... To be encamped at one time in a valley where the heat was almost insufferable, and the water so brackish as to be almost undrinkable—not at all a rare circumstance in parts of Guzerat—at another time to be perched on the top of a hill where the wind blew their tents down, and no water at all to be had.

I met with every kind of difficulty and annoyance; ... I was not prepared for insubordination. ... Some of them refused to take the field, stating that the work was far more troublesome than they could possibly have conceived. ... I handed in the name of the ringleader, begging for his dismissal...as a warning. ... All the surveyors were ordered to sign a contract

[1] *GR. Trig., 1866–7* (14–6; I–LXVI); OBO. Lib. folio a.; Sandes, II (231–3). [2] DDn. 465 (584–6), Jervis to SG., 11–6–49. [3] DDn. 543 (53), 15–5–50.

to serve...faithfully for five years; ... no penalty is attached in case of breach. ... I was directed never to separate the surveyors in small batches...but to employ them in two separate parties...of five young surveyors under the immediate control of a native Superintendent. ... .

At the end of the first working season but a very small tract...had been surveyed, and at a very large outlay. ... The work was actually performed by the two native superintendents, the young surveyors drawing pay for looking on. ... Some idled their time; the others who did take an interest...only hindered the native superintendents...by a repetition of questions. ...

During the rains I pointed out...how necessary it was that they should not only study to retain what they had previously learnt, but to acquire still greater knowledge. ... The young surveyors were profuse in their promises. ... I was compelled to take the field this season without any assistance, both the native superintendents being absent. ...

Owing to the young surveyors drawing...large salaries whilst almost inexperienced in field operations, the outlay...is quite out of proportion to the area...surveyed; the expense is very great, whilst the work performed is small in quantity, and of a second-rate description[1].

The salary drawn by these boys was Rs. 70 a month including horse allowance @ Rs. 20, besides extra allowances during the six months of the field @ Rs. 37, to cover *batta*, carriage of baggage, and pay of two *lascars*.

The Surveyor General was now asked to take over charge, but declined, and recommended that Boddam's party should be broken up;

His operations have proved nearly a complete failure, ... caused by his want of experience ...which has prevented his working a large establishment with proper economy. ... The party is entirely native, and composed of young lads who, however well educated, are totally inexperienced, not only in business but also in the ways of the world. ... To use such materials would be a difficult task for an officer of experience, ... but when the officer selected has not thoroughly mastered his business, the difficulty becomes insurmountable[2].

Boddam's senior superintendent instructor was Hyam Essaji who had been one of Thomas Jervis' surveyors on the Konkan survey before 1830 [III, 126–7, 393]. He had later worked with Giberne in Gujarāt [IV, 242] and then with the Chief Engineer at Bombay [IV, 309]. He was now "an old man and unhappily subject to most painful bodily infirmities, rendering him liable to be prostrated after any very severe bodily exertions. He was always ready and willing to volunteer when any extraordinary work was to be undertaken".

The second superintendent was capable and educated, but took no interest in the field work, being anxious to return to his comfortable and well-paid post as Head Draughtsman to the Chief Engineer[3].

REVENUE SURVEYS: BENGAL

Indians had long been employed on the professional revenue survey as surveyors and traversers. They were treated as belonging to the regular staff in contrast to the *amīns* or measurers of the *khasrah* survey [III, 388–90]. Wyatt writes of his men on the Sāran survey where he had recently taken over charge. He had spent many years as assistant under Wroughton to whom he writes;

With a few exceptions the native surveyors attached to this survey are incapable of executing the various office duties required. ... Their capacity seems to have been compressed in field surveying and copying village plans, and occasionally calculating offsets. ... The native surveyors employed under your...orders on the Muttra and Mirzapoor surveys were far more capable men [IV, 228, 402]. They not only executed the field duties but rendered themselves useful in office, in plotting, triangulating, and testing areas, as well as in working traverses[4].

The Sāran surveyors drew salaries ranging from Rs. 12 to 18, the senior having some six years service. Swiney reports that the salaries of the first seven surveyors or *mutsuddies* of the Midnapore survey ran from Rs. 20 to 25;

All can use theodolite and compass; two can calculate areas; all can protract the field work. They are all hard-working men, and I had every reason to be satisfied with them, both from their work and general conduct[5].

[1] DDn. 546 (39), Boddam to CE., 12–12–51. [2] DDn. 542 (289), SG. to Mil. Dept., 8–3–52. [3] DDn. 544 (644), Boddam to CE., 17–10–51. [4] DLR. 36/31 (181–2), to DSG., 17–11–45. [5] DDn. 482 (130).

He asked permission to employ "six honest and trustworthy men as purtal ameens, each at 25 rupees per month...to revise and report on the ameen's proceedings, ... they being but too prone to be corrupted by the zemindars". The Deputy Surveyor General thought this "both in number and salary extravagant. You can, however, make any arrangements that will ensure accuracy and efficiency, ... provided the monthly sum authorised...is not exceeded"[1].

Conditions in Lower Bengal were extremely hard for surveyors and *amīns*. Many were saturated with malaria, and the contract rates were far from generous [300] ;

The salary of a thakbast aumeen is Rs. 17-8 a month. To realise this amount my measuring aumeen must by the sweat of his brow measure dagh by dagh [IV, 180 n.5] at least 1,200 beegahs of land, and with the probability...of its being erroneously measured when compared with the professional survey, and consequently rejected [303]. ... When the thakbast aumeen realises only Rs. 10 per month, he is three times better off than the measuring aumeen, and with a duty much less irksome[2].

For many reasons Smyth preferred working with regular salaried *amīns* rather than with the more popular contract system. The *thakbast amīns* were employed on the survey of the boundary marks, and not with the measurement of fields [297-300].

In his Rohilkhand party Vanrenen's staff included some 25 "native surveyors", and Burgess expressed a high opinion of most of those on the Delhi survey [264-5].

Their faults are generally of teaching, and from impossibilities being expected of them. They have generally extremely good eyesight, and a steady hand and head for taking and noting observations—very seldom making a mistake—with an unusual amount of patience, but they require very close supervision, and must be allowed to take their time. ...

Khoom Singh—a most intelligent, careful, and honest native surveyor. ... An inspection of the beautiful way in which he has executed the very difficult task entrusted to him in the survey of the intricate watercourses and hill country will say more in his favour than I can.

Hookum Chand—...employed entirely on the maps of the rivers, and...previously similarly employed by the Archaeological Society of Delhi[3]. Nothing could be better than his minute detail book in the plans of buildings, etc.

On the other hand his general survey was not accurate and had to be entirely re-surveyed. He was not re-employed the following season. A third surveyor also had to be discharged for careless work[4].

Amongst those who did exceptionally well with the Bengal parties were—

Lallah Ram, born about 1820, appointed *mutsuddi* in Sherwill's Bihar party in 1835—Sherwill describes him in 1846 as head *mutsuddi*, "far more intelligent and useful" than two of his East-Indian assistants ; "well acquainted with the work in all its branches"[5]. Was drawing Rs. 75 p.m. in 1862 as sub-assistant [441].

Kowla Datt, for promotion to Rs. 25 p.m. ; "This *khusrah* office *mutsuddi* is one of the most useful men in the Department. Quite au fait in the trying work of...boundary comparisons ...professional and *thakbast* maps. ... His activity, assiduity, good conduct, and general usefulness, both in the professional and *khasrah* departments, render him fully deserving"[6].

Hussain Baksh [264] has spent the best and greatest part of his life in the survey, and hard work and exposure has had its effects upon him, and nearly ruined his eyesight. ... He is a highly respectable, deserving old servant, of whom I have always had a very high opinion, but I fear he will not be able to carry on his survey duties much longer[7].

Kirpa Ram, Punjab and Chota Nāgpur ; appointed 1846 ; drawing Rs. 75 p.m. in 1862 as sub-assistant.

Hari Singh, born in 1830, appointed to Punjab surveys in 1852 ; served with Johnstone in Derajat ; drew Rs. 100 p.m. under Anderson in Oudh in 1860 ; died on leave from Dera Ismail Khan ; "one of the most useful men Col. Johnstone ever had under him".

The Surveyor General specially noticed computer Radanath Chackarbutty who had served in Burgess's party in Bundelkhand [267] ;

Lieutenant [Andrian] Vanrenen reports him to be one of the best computers he ever met with, further adding that he was most useful when the records of the late survey were recovered from the rebels, and had to be arranged. Without Radanath Chackerbutty's assistance it would have been impossible...to complete the work as he did last recess[8].

[1] DDn. 482 (96), 12-12-46. [2] DLR. 39/68 (334), Smyth to DSG., 7-9-49. [3] Soc. active 1847-52 ; Ist. *Journal*, 1850. [4] DDn. 485 (7), 21-1-51. [5] DLR. 37/66 (2) ; to DSG., 21-8-46. [6] DLR. 36/27 (104), Wyatt to DSG., 3-1-49. [7] DDn. 485, Burgess to DSG., 24-11-53. [8] DDn. 666 (157), to DSG., 9-1-62.

It was often difficult to persuade the Indian staff to accompany a survey party from one district or province to another. "I had" writes Pemberton from Malda many anxious thoughts about my mootsuddees; three have already given in their resignations, dreading to return to the unhealthy climate of Rajshahi. ... I hope you will be able to supply me with three or four efficient hands and permit me, by way of encouragement, to give a small increase of 2 or 3 rupees each to a like number of deserving men at present with me[1].

This reluctance was pressed by Shortrede when arranging the move of his party from the Punjab to Bharatpur and Sind;

I have communicated the information to my establishment generally, among whom it has caused a small sensation. On enquiring which of them would be willing to accompany me to Sind, they generally declined to go, and would prefer being transferred to Bhurtpoor. The old and best hands declined Sind absolutely [43, 391].

Some of those recently entertained, and now tolerably efficient, on from Rs. 12 to 18, would go if they were increased to Rs. 40, with a promise of leave for six months to visit their homes. One man from Bombay, now on Rs. 50, would go if he were raised to Rs. 100 and made a sub-assistant and, considering his general efficiency and the rates paid elsewhere, this is not a very unreasonable demand. If this were denied he too would prefer going to Bhurtpoor.

The khalasis also...ask for a like increase, and even on double pay I doubt whether they would remain, for in visiting their homes they would have to cross the whole of Rajputana... out of British protection, and this—with their being pretty sure of finding employment nearer home—would render it very unlikely that any...would ever return.

The rates of wages in Sind are at least one half higher than in the N.W. Provinces or in the Punjab, and Hindostan men will not go so far from home except at rates above those commonly given in the country[2].

KHALĀSIS & LASCARS: G.T.S.

The pay of the many hundreds of *khalāsis* and followers employed in the field formed a very large item of survey expenditure, though the standard monthly wage was as low as Rs. 5, increased to Rs. 7 or 8 for skilled signal men, *tindals* and mates. As a general rule each party was allotted a definite sum to cover this expenditure.

Amongst privileges enjoyed by all ranks was the franking of letters for free delivery, and Waugh protested against this being refused at Calcutta;

The privilege afforded some compensation for the hardships of a traveller's life, and enabled them to supply regularly to their families the funds indispensable for their maintenance. ... There are none who are so remarkable for the love of home and of their families as the inhabitants of the Upper Provinces. They will proceed to any distance in search of service, and will live with the utmost frugality and parsimony...to save money out of their salaries, and... acquire the means of maintaining their families. ... The payment of postage would...be felt as a very great burden...at this time on account of their having accompanied my office...about one thousand miles, and the expense of postage is therefore very much increased. ...

I beg the favour...to frank the native letters of this Department as ...under...the Postmaster General of the N.W. Provinces. ... The letters...will be limited to reasonable numbers[3].

In cutting the establishment to the needs of the recess season, consideration had to be given to trained men of long service who were the mainstay of the unit. It had at first been usual to employ them right through recess, granting them leave on full pay every two or three years. In 1844 the Surveyor General introduced the plan of granting recess leave on half pay to those who were worthy[4], and to meet an objection from the Accounts Department he pointed out that

some of the men who attend the signals...require 2 or 3 years training before they can be trusted. ... The places of such men cannot be supplied by fresh recruits out of a bazar. ...

A trigonometrical party does not work for years in one locality. One season it may be employed in the damp climate of Bengal or the terai, the next year in the dry provinces of Upper and Central India, and perhaps the season after among the snow-capped peaks of the Himalayas. ... Captain Du Vernet's party moved from...Mirzapore and Lucknow...to the mountains; another party under Captain Renny moved from Purneah...to Neemuch.

[1] DLR. 36/18 (73), 1-8-49. [2] DDn. 661 (115), to DSG., 18-8-55. [3] DO. 8-6-44. [4] DDn. 453 (111-2), to RMG. Calcutta, 3-1-44.

Under such circumstances these trained men are generally far from their homes. ... They watch for months on the tops of cold bleak peaks, thousands of feet high, exposed to the inclemency of the weather. They carry heavy loads in rugged tracts. They suffer from hunger, thirst, and bad provisions, ... They are frequently exposed to heat, cold, and rain without protection, and...visit...the constant haunts of wild beasts. ...

It can be no easy matter...to maintain a high spirit of zeal...and attach the people to the work. ... When a trained and valuable servant comes forward to ask for leave...the officer in charge should feel apprehensive of never seeing his face again. There is no recourse but to bribe him to return by the offer of half-pay during his absence, or even full pay. ...

A party may be employed in a pleasant country where atta is cheap and the men not far from home. They are then sure to return after their leave. At other times a party may be in a district to which no temptation will induce them to return. ... I have sometimes found their local dislikes so great that I have been compelled to refuse leave altogether lest they should not return. ... No general rule is applicable to this Department. Confidence must be reposed in officers to make the cheapest bargain. ... The only pay rules I recognise are ; 1st., that the sum sanctioned...shall never be exceeded in the monthly abstract. 2nd., that an officer ought to underdraw as much as he can. 3rd., that whatever is drawn for a man must be paid to him and his acquittance taken[1].

The following instructions were given to Strange in Rajputānā ;

Your native establishment will be of the strength sanctioned for the Maluncha Series. You will...draw up a monthly nominal roll to accompany your pay abstracts. The monthly expense...is on no account to exceed that authorised, ... viz., Company's Rupees 491. ... The regulations...authorise the officer in charge to regulate the pay of individuals and the number of persons employed according to his judgement [361]. ...

All useless men should be...discharged on returning to quarters for the monsoon. ... Those men who wish to proceed on leave during the recess may be allowed to do so, whether on full pay or half-pay, according to their merits[2].

Strange pressed for increased pay for his regular establishment to meet the exacting conditions of work through the wild hills and deserts of Rājputāna, and the high local rates, but the Surveyor General could not agree ;

When wages are raised to a standard above the working level, the inevitable result is to... undermine...efficiency. ... There is a certain natural standard. ... When its conditions are satisfied men always work cheerfully. ... This standard...[is] for tindals, Rs. 10—for heliotropers, Rs. 7—for lascars, Rs. 5—and there is always some risk in departing from these rates. ... I could cite many cases in which men previously most useful...have been spoilt in a short time after receiving more than ordinary wages.

Moinuddin—a very smart man—trained up from boyhood by Captain Renny Tailyour. He was an excellent tindal on Rs. 10, but the late Lieutenant Walker raised his wages to Rs. 20. ... Moinuddin would not stay with Mr. Lane at Darjiling, but clamoured for leave to go home. ... He went and lived a few miles off, where he shortly after died of fever and dissipation.

A tindal is required to be a hard-working man who looks after others, puts his own shoulders to the wheel, and infuses his own spirit into labourers. This he can only do as being one of the class himself, and on Rs. 10 he is respected and comfortable. Give him Rs. 15, and he rises to the grade of moonshee, or the literary class. ... He will then most likely run into debt, and becomes a ruined character. I have seen this happen several times[3].

From the Coast series Peyton complained that pay was two months in arrears ;

As the greater number of the native establishment receive only from 3 to 4 rupees per month, the long arrears...entail a very great hardship upon them, ... They are fast falling sick owing to the precarious food and scanty covering they...depend upon, and being now out in the field they are even precluded from...assistance from either friends or relatives. ... Longer delay would aggravate the mischief, and cause the prostration of the whole...establishment[4].

After transfer to the Coast Series, Strange complained of the local men and asked for reinforcements from Upper India. The Surveyor General suggested recruitment from Chittagong ;

The barkandaz guard...was intended in lieu of a military guard. ... To use the men as chaprasis is quite a mistake. Fourteen chaprasis, with a jemadar and naik is immensely beyond what the highest dignitaries in the land are allowed for state. ... The members of the party should be comfortable. Trustworthy barkandazes are required to aid the civil assistants

[1] DDn. 466 (237–41), SG. to MAG., 7–6–49. [2] DDn. 493 (225), SG. to Strange, 8–9–49. [3] DDn. 616 (218), 22–8–51. [4] DDn. 589 (109), to SG., 9–12–52.

in their several duties, to escort treasure, procure rassad [food supplies], and convey orders. ... Even in recess I should wish gentlemen...to receive every attention and assistance.

The high pay of the jemadar is intended to...secure the services of a man who can read and write, to act as munshee to keep accounts—assist in maintaining your relations with the native authorities—and collect local information. ...

If nothing but Hindoostani men will suit you, I...recommend your confining your recruiting to the districts such as Monghir and Bhaugulpoor, the climate of which differs less from that of your scene of operations than the arid districts. ... The men of Chittagong are...well suited to moist jungle climates— ... thrive best in the rice countries—and...are as good for our work as any men of Hindoostan. ... I have had very good men from the Madras side. ...

The wages of Chittagong men are very high compared with up-country wages, and more particularly with rates of your district. ... These men were enlisted at 6 rupees per mensem each, ... but I do not think they will stay for less than 7 or 8 rupees. ... They live expensively, and it is their higher scale of feeding which in fact exempts them, as it also does the Malabar men, from malarial influence. ... They have stronger constitutions to resist that influence. ...

It might contribute *materially* to...attach a native doctor to each of your strong detachments. .... This season you will have two parties detached on secondary duties, ... neither ...within reach of medical aid. ... I am therefore prepared...to recommend the addition of two more native doctors to your party, on the usual salary of 30 rupees per mensem. ...

The doctor in medical charge of the whole party should have a salary sufficient to induce a superior person to become attached to the party[1] [IV, 404 ; V, 244, 361, 364–5].

It was found better after all to recruit locally from Orissa.

Nicholson reported great difficulty in finding suitable men for service in Assam where the people of that country would not face the work ;

Men from Monghyr and Bhaugulpore...suffer even more from the climate than the up-country men. ... I introduced last year...about 30 Dangars, inhabitants of Chota Nagpore, who stood the climate well and proved very useful as carriers, but though every inducement was offered...to become heliotropers and lampmen, not one ever shewed any inclination to make himself useful in this respect. ... Assamese...eat and smoke opium all day ; their employment is out of the question [462 n.2]. ... The most feasible measure is to obtain Chittagong lascars who are naturally intelligent and easily trained, ... but...they demand high wages[2].

Chittagong men could get Rs. 12 p. m. on steamships or on the railways and Lane preferred recruiting *dhāngars* from Hazāribāgh, "a hardy and faithful race but, ... the journey...takes about a month, ... for which period they must receive wages" [362][3]. Such Hazāribāgh *khalāsis* were doing grand work with the survey parties in Assam and Burma more than sixty years later.

Only in very special cases was it possible to obtain pensions for long service [IV, 412], and the Surveyor General applied on behalf of

Narain flagman, the only man remaining of the old Madras establishment of Colonel Lambton. ... He appears to have been entertained in 1821, and has ever since...been engaged in the active and laborious duties of this Department. There is nothing...against him now save impaired efficiency arising from advanced age and wear and tear in the public service. ...

I recommend...that a small pension may be granted to him...[or] a liberal gratuity[4].

A special pension was obtained for *dafadar* Rāmdin of the triangulation detachment in Kashmir who fell over a precipice in the Pir Panjāl [226] ;

On being taken up from the fork of a tree into which he had fallen, the injuries...were [found] very severe.. .. It was very doubtful whether he would survive, and...impossible he could ever be fit for further service. ... He is a sadly mutilated cripple. ... He was one of the best and smartest men in the Department. ... I earnestly recommend...pensionary provision[5].

Rāmdin had 17 years service, drawing Rs. 9 p.m. during his last two years.

TOPOGRAPHICAL PARTIES

Under the Madras rules that governed the Ganjam and Hyderābād parties, each officer and assistant had the pay of a fixed number of *lascars* included in his monthly salary, and this *lascar* allowance was the same whatever the work, and whatever the

[1] DDn. 691 (94), 12–8–56, paras 47–8, 95–7. [2] DDn. 604 (357), 11–9–56. [3] DDn. 702 (76), 19–5–59 ; *dhāngar* = people of Chota Nāgpur hill tribes ; v. *Hobson-Jobson* sv. *dangur*. [4] DDn. 547 (235), to Mil. Dept., 5–6–54. [5] DDn. 716 (5), TGM. to SG., 9–1–57 ; ib. 643 (143), SG. to Mil. Dept., 13–1–57.

nature of the country. In 1850 Saxton asked for an extra squad, to be employed at his own discretion, and Waugh obtained authority for an increase of 1 *dafadar* @ Rs. 8 — 3 heliotropers @ Rs. 6 — 4 @ Rs. 5 — and 4 under training @ Rs. 4 — besides 2 *harkaras* @ Rs. 5 [1 : 18 n.5 & index].

The past season's survey...is so superior, both in...quantity and quality, to what has been previously accomplished...and is so creditable to Lieutenant Saxton's management, ... that... I now feel...he would be enabled to produce a much greater outturn of work if the small increase of establishment...were to be granted[1] [283].

A year later Waugh asked that the Madras system should be abandoned ;

The officer in charge receives an allowance of Rs. 43–14–0 per mensem for 1 tindal and 6 lascars who carry the instruments, ... and each sub-assistant is allowed Rs. 18–7–0 per mensem for 3 lascars who carry his planetable, etc. ... The original idea must have been that by this arrangement the native establishment would vary with the number of surveyors. ...

By attaching the lascars, however, to individuals, they partake of the nature of private servants, and no efficient control can [be maintained]. ... In the case of a surveyor falling sick, the Government not only loses his services, but those of his men. ... Since the suspension of the Hyderabad survey some of the surveyors have been brought up to Bengal [363, 421], and their claims to lascar allowance...has brought the subject more prominently to my notice. ...

There cannot be a question of the superior efficiency attainable by uniting the native establishment under the control...of the officer in charge. ... The lascar allowance should be abrogated, and a regular native establishment substituted as in the Bengal survey.

The pay roll would then stand at Rs. 280 ;

1 *tindal* @ Rs. 8 — 12 1st-class flagmen, heliotropers, and chainmen @ Rs. 6 — 12 2nd-class, @ Rs. 5 — 8 sub-assistants with 1 lascar each @ Rs. 6 and 2 @ Rs. 5 — 2 *harkaras* @ Rs. 6 — Extra establishment during the field season, 12 carriers @ Rs. 6[2].

The new arrangement came in from 1st July 1854, with provision that

the new permanent establishment is not to exceed Rs. 280 per mensem, with an addition of Rs. 72 for labourers and carriers in the field. ... The number of men...and the salaries are left to your own discretion. ... This rule will enable you to engage a greater number of men in the field. ... It will be proper to attach a good tindal and 12 1st-class heliotropers at least by good wages, but—a distinction should be made between their pay in the field and quarters.

It is the practice in Bengal to give as many men as can be spared leave on half pay during the recess. ... You may be able to exhibit a considerable saving in quarters, but the full force of your establishment should be maintained in the field[3] [452–3].

REVENUE SURVEYS

In the revenue survey parties each officer in charge was allotted definite sums for the respective establishments of his professional and *khasrah* work. He was able to recruit a good class of chainmen and *lascars* because the more intelligent had prospects of promotion to become surveyors [451]. This had not been effected however in the Purnea party where Pemberton found the *khalāsis*

a perfect rabble. There were only 22 old hands, one of whom called himself a Jemadar and used to make a traffic of khalassees' situations by selling them to the highest bidders. Consequently the men I found here were worthless. I have nearly got them into order now[4]

Foodstuffs must have been very cheap to allow these rates of pay—

Line-cutters ; *tindal* Rs. 6—*khalāsis*, Rs. 3–8 to 4—orderlies drew Rs. 3–8 a month.

Boundary parties, *tindals* drew Rs. 5 or 6 — mates, Rs. 4–8 — *khalasis*, Rs. 3–8 or 4.

The interior parties, 2 *tindals* Rs. 5 p.m. for 12 months — 5 mates Rs. 4–8 for 8 months, with half-pay for the other 4 months — 5 *khalasis* Rs. 4 p.m. for 8 months with half-pay for the rest of the year[5].

Small pensions Rs. 1–4 to Rs. 6 were granted to the survivors of an attack made on the squad of one of the Indian surveyors of Burgess's party in 1857 ;

Rs. 6 was granted to Moomtaz, the only son of the late native surveyor, Torab Ally, who died from the wounds received. ... The pension granted to Moomtaz being one-sixth of his father's salary, to continue until he attains the age of 18. The remainder are khalassies[6].

[1] DDn. 542 (319), SG. to Mil. Dept., 29–7–52. [2] DDn. 577 (11), SG. to Mil. Dept., 1–9–53. [3] DDn. 592 (58), 8–6–54. [4] DLR. 36/17 (45), to DSG., 10–11–46. [5] Birbhūm, 1848 ; DLR. 37/62 (31), from Tickell, 5–12–48. [6] *GR. Rec. 1857–62* (73); NWP. Govt. letter, 27–9–59.

CHAPTER XXIX

SICKNESS & HEALTH

General — Assam — East Coast.

THE progress of the surveys of India cannot be fully appreciated without an account of the appalling wastage and suffering caused by sickness and disease, the unbelievable ignorance of the origin and nature of tropical diseases, and the futility of bleedings — cuppings — blisters — and nauseous medicines [IV, 435]. Nothing was known of bacteria, or the disease-carrying properties of flies, mosquitos, and bugs, and little heed was taken of the elementary precautions of boiling water or screening food [459]. Dysentery, malaria, typhus, and typhoid were rampant, and none were more exposed than the surveyors.

James Abbott, distinguished Commissioner of Hazāra, tells of his early experiences as revenue surveyor in the jungles of the Rohilkhand *tarai* [IV, 416–7];

> Towards the close of the year 1838...I proceeded...towards the right bank of the river Sarduh to survey the adjacent forest lands. Wearied of the flat, tame, over-cultivated tracts ...the idea...was extremely welcome, although considerable difficulty was apprehended...in the seas of reeds and lofty grass through which it would be necessary to cut lines [261].
>
> But my establishment of natives heard of it with very different feelings. The tracts bordering this forest, even where cultivated, are at certain seasons extremely inimical to the human constitution. When the mass of decaying leaves, which for many centuries the forest has been accumulating beneath its shade, has been completely saturated with the torrents of rain poured down by the monsoon, and the scorching sun...blazes upon this vast hoard of corruption, exhalations of a deadly kind are raised, which act upon the frame of man as the most virulent vegetable soil which may ever be seen floating upon its surface, and creates indigestion and low fevers which carry off large numbers yearly [466].
>
> The natives of the healthier districts adjoining have...greatly exaggerated an evil. ... They know also that nature has peopled these forests with wild beasts, and have added...ghosts and demons and wizards of their own imagining. The result is the most slavish fear that can be conceived. As soon as my purpose was declared, a large number of my native surveyors absconded, preferring the loss of employ to...the horrors of the forest[1].

Renny writes of repeated sickness right through his Maluncha party when working through Birbhum and the Santāl Parganas. His assistants Rossenrode and Webb had retreated to Bhāgalpur for medical treatment ;

> It does not appear that the...country in which we are engaged is generally unhealthy, but the water being chiefly obtained from tanks or stagnant pools and watercourses is liable to be injuriously affected by decayed vegetable matter, and is reputed to be prejudicial in places.
>
> The water in the vicinity of the hill station of Beharinat appears to engender dysentery, as all parties...sent to that station have generally suffered from that complaint, and the germ of Mr. Rossenrode's illness is supposed to have been contracted in the neighbourhood of that station where he was detained for several days.
>
> [a month later]—In consequence of great sickness...I...moved out of the jungly tract, ... four of my khalasis having died within the last few days of jungle fever, and one fourth of the remainder being now on the sick list, which is increasing daily. ... My operations are already impeded by a want of lampmen, in which class the casualties and greater part of the sickness have occurred. ... Mr. Olliver...has been suffering for the last week from intermittent fever. ... I...had no reason to anticipate great sickness as the inhabitants...did not complain of any general unhealthiness at this season[2] [14].

[1] *Tales of the Forest* (intro) ; London, 1853 ; covers *The Lotus Walker* and another poem, first pub. *c.* 1833, *EIUSJ.*, Calcutta ; Abbott worked off early debts by such poems and essays. [2] DDn. 514 (23, 37), to SG., 28–3–& 19–4–44.

When Logan started work on the North-East Longitudinal series, the Surveyor General warned him that survey parties had suffered so much embarrassment from jungle fevers in the tarai that I...warn you against entering the unhealthy tract before the 15th November, or remaining longer than the 15th April. The rest of the season...the party can be employed on filling up the triangulation with secondary work. ...

With regard to jungle fever, the best precaution is to keep moving, neither remaining long yourself, nor suffering others to remain long, in one place. The symptoms are bilious; ... in fact it is a bilious, constipated fever, and the remedy in the commencement is an emetic, followed by calomel and purges. If neglected the treatment becomes more complicated[1] [459].

Waugh thought the sickness on the Gora series might have been avoided [12];

Of all the difficulties with which trigonometrical operations...have to contend there are none which oppose such serious obstacles...as...jungle miasma. By its ravages whole bodies of trained men are prostrated in a few days, and although it does at first sight appear harsh and unfeeling to impute blame to an officer in such circumstances, still...as regards insalubrity ...the Gora Series is not more unfavourably situated than any of its neighbours [365–6]. ...

Lieutenant Garforth...stationed a large portion of his establishment at too early a period... on the Kaimur Range, ... which...proved to have been injudicious. ... The disaster...occurred at the outset and completely disorganized his party [459]. ...

There are no class of persons in the world...who are more exposed to sickness...than the members of this hard-worked department. They are compelled...not only to traverse and explore tracts of notoriously dangerous character, but to linger in such pestilential climates for months together. ... The due maintenance of these...parties is a measure not only of humanity, but of real economy to the State. ...

The medical charge of these several parties...is confided to native doctors, to the nomination of whom...no principle of selection is observed. There are many excellent practitioners among the native doctors in the service, men whose skill and experience...senior officers are unwilling to part with. ... The officer in charge [of the Gora Series] made several fruitless attempts to obtain a regularly educated native doctor, and was compelled as a last recourse to entertain a compounder...totally unacquainted with medical science. ... Orders should be issued for selecting...experienced medicial subordinates for so important...a charge.

With reference to the reputed insalubrity of the districts through which Captain Hill's operations will pass, I...suggest...that a Sub-Assistant Surgeon should be appointed to the medical charge of his party. ... I am not prepared to suggest so expensive a measure...to the Gora series, because the unhealthy tract is very limited in extent, ... and...ought to be traversed in six weeks. ... The most favourable season may be chosen, and after it has been completed the party will enter...one of the healthiest parts of Upper India. ... I would, however, suggest that a well qualified native doctor should be appointed...in lieu of the compounder[2].

He rebuked Garforth for entering the Kaimur Hills without precautions;

The proper system...when you are working in such countries is to proceed with great energy and expedition. ... The men ought to...obtain drinking water from the nearest villages, and the detached parties should...hut themselves as a protection from the dews at night [459]. ...

The best plan is to relieve detached parties as soon as they fall sick, and immediately administer the usual remedies. ... When a particular station has a notoriously bad reputation, I always...relieve the man at that spot once a week. ... The services of a detached heliotrope man may perhaps be lost for a time, and that is the whole extent of embarrassment...likely. ...

It is very essential...to preserve a cheerful and firm aspect yourself, whereby you will inspire the men with confidence and energy. ... No benefit whatever can be expected from a residence in cantonments, because...the best means of cure is change of air and scene. I have always been accustomed to take the management of the sick into my own hands [20, 464][3].

This was passed to Armstrong who hastened to justify his retreat to Benares;

On my arrival at Barhani...I felt pains in my limbs...accompanied with a fever which laid me on my bed. Seeing that the fever had not abated on the 26th, I procured a palkee from the village, and about noon...proceeded with every inconvenience towards Benares, which I reached about midnight. On the way I was very sick, and brought up a quantity of bile. ...

With no medical aid of any description beyond a few doses of jalap [purge], ... and aware... that my case which nearly proved fatal in October of 1844 was one which called for instant professional aid, I did not scruple to...seek a remedy which I did not possess in the field. ...

A complaint so insidious...could not bear procrastination, ... and I have not so much strength of mind to see it assume a serious turn, and delay its cure till severity proves dangerous. ... I had no amusements to seek at Benares, no friends or acquaintances to see and pass the time

[1] DDn. 499 (173–4), 25–7–45. [2] DDn. 452 (301–25), 22–8–45. [3] DDn. 491 (247), 12–9–45.

with. I went for medical aid, ... and in doing so I put myself under obligation to a perfect stranger who afforded me a shelter with a hospitality which I shall remember with gratitude. ...

Since 1 o'clock of yesterday morning...I have been laid up with a bilious attack, having all the symptoms of cholera, and am now in bed, too weak even to sit up and write this letter to you. ... Notwithstanding my indisposition the minor triangulation is progressing. .

He was still in the field in June pushing on his work in wretched health ;

I should not wonder if September is ushered in while I am engaged on the task. Delicate as my health has been since my severe sickness of October 1844, ... I cannot say how far it will permit me to stand the mutations of weather—...the heat of the noon-day sun...or the damp of an encampment at night—but so long as it will permit me, I shall devote my...service to the task, and leave the field only when no longer able to bear the inclemency of the weather.

[a week later]. Within the last few days I have been feeling rather indisposed, with a very foul tongue and general lassitude. ... and I...believe that the change of weather...has had some influence in creating this change in my health. ... I have...come to the resolution of soliciting...permission to proceed to Allahabad about the close of the month. ...

In your letter...you state that earlier than the 2nd of August you cannot hold out any hope of my discontinuing my labours in the field, though this is...much beyond the usual time. ... I must, however, seek relief at the hands of the Surveyor General[1].

The Surveyor General agreed that he should be allowed to close field work ahead of Garforth's own party [365–6], but Armstrong was again laid low ;

I was much distressed on the 21st by a bilious attack. ... In consequence of the rain having come on in the morning I was prevented from marching...till about mid-day, and when I had accomplished about half the journey I was attacked by bad bowels and nausea, and compelled to seek repose under a tree, where I remained till near sunset before I felt any relief. When my tent had arrived and was pitched, ... a palki was brought for me and I was conveyed... to my camp. That night I took a couple of pills and followed that next morning with a dose of jalap, but I continued indisposed for nearly three days[2].

The Surveyor General comments on the frequency with which Wroughton's Calcutta office staff stayed away on the plea of sickness ;

When I first assumed charge in Calcutta, the frequent occurrence of sickness struck me as remarkable, being so very different from what occurs in the Upper Provinces, where sickness is of rare occurrence. ... I found that every office in Calcutta was similarly circumstanced, and the number of deaths which occurred in our office left no doubt...that the climate of Calcutta is very prejudicial to general health.

At the same time, there is little doubt that the temptations in a large city, and the vicinity of domesticities, together with facilities for obtaining extra work, are strong motives to induce those who are not actuated by strict...duty to absent themselves on trivial grounds.

In my office in the field [Allahābād]...all the above temptations are wanting. Indeed for more than half the year the attendance at office is voluntarily extended from 9 o'clock in the morning to 5 o'clock, and sometimes even to 6 o'clock, in the evening, and absence on account of sickness is so rare as to be hardly worth noticing. ...

[In Calcutta] absence on the plea of sickness continues very frequent in the case of native draftsmen, as this class...have very great temptations to stay at home for...private jobs[3].

During 1851 the Surveyor General issued a note on preservation of health[4] ;

Although...the occupation of a surveyor may be...more healthy than any other...life in India on account of the fresh air, constant exercise, and interesting...employment, still there are some tracts...in which survey parties are exposed to...endemic diseases. ...

Such tracts cannot be avoided. ... It becomes an important matter to consider...the protection of survey parties from jungle fever in the first instance, and secondly the proper treatment...in the event of the disease breaking out...in camp. ... As the assistance of medical officers has never been granted to survey parties, even...in the most unhealthy places, ... surveyors are of necessity thrown upon their own resources. ... Fortunately the treatment of jungle fever...is sufficiently simple, and will prove successful in 19 cases out of 20, though if once the disease be allowed to gain head, it requires the utmost skill...to reduce it. ...

In the Longitudinal series from Seronj to Calcutta, ... Mr. Rossenrode...carried his party through with hardly any casualties, owing to the precaution...of making his party breakfast before marching, and treating every case promptly as it occurred. The party which followed... suffered severely from the neglect of these precautions [III, 262–4]. ...

[1] DDn. 494 (9–11, 46–7), 20–12–45 & 4–6–46 ; ib. 496 (165), 11–6–46. [2] DDn. 494 (61–2), 26–6–46. [3] DDn. 473 (62–5), SG. to DSG., 21–12–45. [4] v. DDn. 588 (65), SG. to Saxton, 23–7–51.

The revenue survey party conducted by Major Wroughton in the same insalubrious tract along the Son suffered severely, but the work was never paralyzed owing to Major W.'s medical skill for which he was remarkable [IV, 228, 476]. In contrast, ... we have three signal instances of failure in the mere attempt to start the triangulation of those districts[1].

The habit of breakfasting the whole party before starting has been proved, ... and to this as well as to the superior stamina derived from good living may be attributed...that Mussulmen are less subject to the influence of miasma than Hindoos, who cannot conveniently cook oftener than once a day. ...

Dr. Coombe's work entitled *Physiology of Digestion*, page 63, ... recounts instances...of the advantage of attending to this rule. ... The case might be cited of an officer of the Survey Department who had made it a habit to march fasting. Crossing a very unhealthy tract by forced marches he seldom reached his ground before 2 or 3 p.m., by which time he was quite exhausted. The consequence was a severe illness, which obliged him to go to sea. ...

When the weather is very hot, it is usual to move at night, to save the men from exposure to the sun. ... It is usual for gentlemen to take a cup of coffee and a biscuit, and...it is a good plan to fill one's pocket with biscuits, gingerbread nuts, or something of that sort, and carry a bottle of cold tea, or cold weak coffee without milk. ... Surveyors are liable to be out all day. ... It is desirable to be accompanied with a basket containing sandwiches, etc. ... The men should have a lunch of parched gram and sugar. ...

Most officers take these precautions for themselves. They also sleep under canvas, protected from the dew, and upon beds raised above the exhalations of the ground [456]. ... The native establishment and servants may be laid up with fever and brought to the verge of death without the officer in charge, or assistants, being effected in the smallest degree.

After quoting instances when the officers escaped whilst their men suffered severely, Waugh concludes ;

It is difficult in the case of Hindoos to get them to cook their meals at proper times, but as far as possible it should be done, and all surveyors who are careful of their men...protect them from dew at night, and...furnish them with straw to sleep on. ... Camel carriage in Upper India renders it easy to carry charpoys...and when men are detached to show signals...they are always directed to hut themselves. ...

It is usual in the case of persons very susceptible of fever to fortify themselves by taking quinine while they are employed in unhealthy localities, and this is said to have a good preventive effect [II, 360 ; V, 216, 255, 465].

In the regulations for the Survey Department it is laid down that the field season shall extend from the 1st October to 1st July. ... The terai and other places most celebrated for insalubrity are generally safer on the 15th of November. ... It may be prudent to defer the commencement of work till the 1st or 15th December [365–7]. Care should be taken...to put the party under canvas by 15th October. ... By this means every individual...will get inured to the vicissitudes of camp life. A sudden change from houses...to tents...is apt to affect health. ...

Cleared and inhabited spots should be preferred for camping on, or high open spots, and the vicinity of rivers avoided, as well as closely wooded places where there is no circulation of air. ... Enquiry should be made for good drinking water. ... Many people use boiled water, a precaution which even the native inhabitants practice in some parts. In some parts...well water is considered the most wholesome. ... River water is dangerous.

European science attributes these fevers to malaria, while the natives consider deleterious water to be the cause. ... A detachment...was encamped for 3 weeks in October on a hill in the Kaimur Range. There was no potable water nearer the Son, about 8 miles off, and upwards of a thousand feet lower. ... The party...resorted to pools in the hollows...which.... approached exhaustion. ... The whole detachment was prostrated with a bad fever which came upon the camp like an avenging angel. ... Other detachments in the same range...did not suffer in the least [457].

Jungle fever is a bilious remittent, commencing with headache, pains in the limbs and loins, heavy langour, ... yawning, and fits of heat and cold. The tongue is white, the eyes yellow. There is...pain or fullness in the stomach, nausea, and the pulse frequent and small [457].

The prescription which has been found most efficacious will generally suffice for a cure in all mild cases. Tartar emetic, 2 grains[2]—Calomel, 3 to 5 gr., to be given immediately, and followed by a dose of compound jalap, or black dose, next morning [IV, 425 ; V, 457–8].

Relapses are always dangerous. ... As jungle fever is accompanied with...tendency of blood...to the brain, one should be cautious in administering quinine until all head symptoms have subsided. ... Should quinine have been given at too early a stage, and the patient suffers

[1] Karara Series [IV, 69 ; V, 11]. [2] *potassium antimonyl* ; v. *Ency Brit.*

acute pain with great heat in the head, the best plan is to lower the system by...epsom or glauber salts—tartar emetic. ...

... The state of the head should be carefully watched, for the disease sometimes terminates fatally by the bursting of a vessel in the brain. ... If the fever runs high...apply leeches to the temples (say 4 to 12 leeches)—shave the head—and apply cooling lotions. ... If there be delirium it may be desirable to bleed from the arm, but...bleeding is a dangerous practice for non-medical persons to meddle with. ...

If the pressure on the brain appears considerable, a blister should be applied to the junction of the head and neck. The writer once had a case in which...a bearer remained insensible 4 or 5 days but ultimately recovered from the effects of a blister. ...

The diet all this time must be confined to tea, soda-water, sherbet, barley-water, toast and water, sago, etc., and for natives something analagous, such as kanji-water. ... Everything stimulant should be avoided for several days. ... It is usual to give quinine as soon as... symptoms have subsided. ... In the height of the fever quinine would be dangerous. ...

When the disease attacks a camp it is not an unusual thing for a party to become so alarmed as to march away in all haste, and if the officer in charge is ill himself he perhaps will start off immediately in a palanquin to the nearest station for medical aid. Now this is precisely what should not be done. Rest and quiet are the most efficacious elements of cure. ...

In the Nirmal jungles...the...lamp and heliotrope men who went to Shivni station were completely cut off on account of the country being infested by tigers. Being taken ill, they could not send word, yet...continued to show signals in the most plucky manner. When I arrived at Shivni the men were like spectres. One died next day; ... the others got well. After that I supplied physic to the detached parties and no more accidents occurred. ...

The proper time for leaving the jungles...is not so material...as the time for commencement; ... a sufficient quantity of work should be done before any party breaks up. ... About the 15th April, when the leaves fall and the hot weather sets in strong, considerable sickness may be expected, but not generally of a dangerous character. ... Last season Mr. Peyton, marching his party across the terai in the middle of April, had several cases of fever, and one private servant died; marching through the same tract a month later not a man suffered. ... No party should break up before the 15th April in the worst ground. ...

Survey parties are usually attended by native doctors who compound the medicines and attend to the orders of the officer in charge. ... Some are pretty skilful in the practice of medicine. ... The attendance of the officer in charge on the sick...cheers up the patients. ...

Success...depends on—1st. the comfort of the establishment; 2nd. avoiding to encamp at unhealthy spots; 3rd, prompt medical aid. The party should be provided with sufficient tents. The men should have charpoys or straw to sleep on. Nourishing food should be supplied. No one should be exposed to malaria on an empty stomach, or work when exhausted by long fasts. Great care should be taken to select good encamping grounds with wholesome water which should be boiled if necessary [466].

The men...should complain the moment they feel symptoms of jungle fever, and then the calomel and tartar emetic should be instantly administered. ... Detachments should be supplied with medicines ready weighed out.

Lastly, ... although change of air is good for convalescents, ... still, while fever is in the system, rest and tranquility are necessary. ... It may look much more manly to be able to brave malaria on an empty stomach, but what is the use of hardy habits...if no work is done? It is very good to be able to brave an Indian sun with impunity, but...an umbrella will enable a man to accomplish more survey work than he could without. ... The quality of work done is the only criterion; ... unless a party takes the field well equipped with tents and other comforts, health is endangered, and the interests of Government are sacrificed[1].

There were few parties of the trigonometrical survey which did not suffer the ravages of malaria at some time or another. Whilst, perhaps, the parties of the tarai, lower Bengal, Assam, and the East Coast were the worst sufferers, the Bombay party had two wretched seasons in Gujarāt, Rivers writing in April 1846;

Messrs. Sanger and Da Costa and about 20 of the establishment were attacked, the former so badly, and medicine having no effect, that I was obliged to get him carried off to Surat. I also got it here, though not as yet severely. ... But I daily got worse, and...was so weak as to be unable to rise, far less to take observations. I waited three days, ... but the only change was that of the fever from an intermittent to a continuous kind [55].

The establishment also was no better, for though many got over the fever, others kept getting it, and those who recovered the fever suffered from weakness.

[1] DDn. 598 (166), SG.'s Circular, 23-7-51.

I was taken in to Surat, and having remained there a week was sent on here [Mahābaleshwar] on medical certificate, ...

From the parallel of 20° 30′ there are a succession of deadly jungles called successively the Dang, the Rajpipla, and the Barria, places notorious for their climate, and if entered in the hot weather when it is supposed they are less dangerous, it is impossible to see anything on account of their being always set on fire in these months [55, 366][1].

James Leigh writes from the Hyderābād survey ;

My illness and sufferings...commenced with a severe and violent attack of inflammation of the lungs. Pneumonia and subsequent diarrhœa, together with the powerful means and remedies...and the salvation by mercury, to a severe extent causing ulceration of the throat and enlargement of the glands of the neck, so effectually prevented my taking nourishment for upwards of a month, and being even now only able to swallow with difficulty and pain—nothing more than plain milk—I am reduced to such a state of emaciation and debility that I can scarcely walk ten paces without support. ...

Not being able to sit up to reply to your letter, I am obliged to get another to write for me. ... I am most anxiously awaiting your return to Ellichpoor when I earnestly hope you will...favour me with your assistance in obtaining for me my pension, as I fear I never will be able again to perform my duties efficiently. ... This is the second attack of severe illness I have had within the last 12 months, besides which I also suffer from piles frequently[2].

Indian doctors attached to survey parties were just as liable to "jungle fever" as others, and we find frequent record of their succumbing to a wave of sickness just as their services were most required [16, 367]. On the other hand their presence was invaluable in establishing confidence. Montgomerie recommends Lachman Singh for promotion from Rs. 30 to 35 per month. He had been attached to the Kashmir series since its commencement. ... Cholera and smallpox attacked the camp at various times, and on each occasion Lachman Singh behaved well, and during the whole ten years...not more than eight men of the establishment have died[3].

ASSAM

Du Vernet describes the unhappy start made by the Assam party at the end of 1852 and the risk of taking the field too early ;

Mr. Nicolson arrived...at Kochabari last season on the 2nd December, and he had 50 men in hospital by the end of the month ; thus by being on his ground too early he had his party crippled for the season [30].

In Col. Everest's time, anxious to commence my survey early, ... I entered the low hills at Hardwar about the 15th of October instead of waiting until...the following month, and I returned in a few days with a severe jungle fever, and brought back about fifty men of my party in the same state [IV, 71]. Mr. Nicolson, also, on that occasion suffered from fever and did not recover for many years from the effects. ... Colonel Everest censured my ill-judged zeal, and pitied my unfortunate men and my assistant whom I had unnecessarily exposed.

Lieutenant Walker...was a young and inexperienced officer who, by incautiously exposing himself to noxious vapours in the vicinity of Darjeeling, lost his life at an early age [19][4].

Thomas Fisher writes after more than 25 years in Assam [III, 447–8] ;

The unhealthiness does not appear to depend upon the presence of forest or jungle. Some of the most deadly parts...are perfectly clear, and exhibit...all the conditions which are supposed to be favourable to health. Open, dry, well-cultivated plains, free from marsh, and watered by clear running streams. These are the characters of the Dooars, or tract extending along the foot of the Bootan mountains, and yet they are even more unhealthy than the forests[5].

Constant sickness in the party compelled the resignation of the brothers Thomas and Henry Berrill and of Deveria, and the transfer of Charles Shelverton during 1856. Nicolson himself had to take sick leave at the end of the year. Lane took over charge and at once applied for the services of a capable medical officer. Dr. Lee from the Marine Department joined at Goālpara about April 1857, but unfortunately did not remain many months, and for several seasons the party remained without any medical assistance whatever[6]. Jenkins, the Chief Commissioner, lent Lane

[1] DDn. 325 (407–10), 24–4–46. [2] Leigh to Mulheran, 21–1–62 ; Leigh ret. on pension, 1863 ; b. c. 1815. [3] DDn. 51 (128), TGM. to SG., 15–2–65. [4] DDn. 602 (165), to SG., 25–6–53. [5] DDn. 325 (509–13), to SG., 29–6–47. [6] DDn. 705 (17), Lane to Med. Bd., 27–2–57 ; ib. (90), Lane to DSG., 6–9–57.

a very useful little work which [writes Lane] would also prove invaluable to the Coast and Ganjam survey parties. It is called "Narrative of the Niger, Ishadda, and Binue exploration", about the most deadly fever region in the world[1] [Central Africa], and advised me to conform to the preventive measures therein inculcated. One of these is 'quinine in sherry to be taken twice a day'. I have even tried quinine in rum and water for the natives, and found it capital. ... The tindal of this party...eats plenty of masalas [spices], and always takes rum in moderation, and has never been sick or sorry for years[2].

The medical value of stimulants was officially recognized, and in 1858 the Revenue Board passed a bill for port wine for Pemberton's party [246][3].

The Surveyor General fully realized the difficulties in Assam ;

Subsequent to 1857 the progress...has again diminished owing to the difficult character of the country and its destructive climate. Persons residing in Assam become acclimatised because they live in the more salubrious localities or, as travellers, pass rapidly along frequented ways, but a surveyor has no escape. ... He must penetrate and linger in the most deadly places, and the recurrence of such serious attacks of dangerous fevers...saps energies of all subjected to their evil influences. I see no remedy...except by a system of frequent reliefs and...leave to those whose health is sacrificed. ... These recommendations have been overruled, but it is my deliberate conviction...that some measures of alleviation must be conceded or these important operations will never progress. ....

I myself...have been employed in the most...unhealthy tracts—the Nirmal jungles, the Sirgooja and Sungrowly tracts, and country at the sources of the Narbada, Sone, and Mahanadi rivers— ... the Mahadeo Hills [III, 242]—the terai—and parts of Sind. Except the latter my health never suffered [44]. But though unscathed myself, I was surrounded by the dead and dying, and the difficulties of carrying on work at all under such circumstances were perfectly appalling. ... Such risks are of no material importance for one or two seasons, ... but when continued year after year, as they will be in some of the work remaining...on this series if special provision be not made, disaster will ensue[4].

EAST COAST

The Ganjam survey had been suspended in 1841 owing to the break-down in health of Thorold Hill under whom it had been carried on spasmodically since 1834. Hill's work lay in the jungle-covered hills of Goomsur which had been carefully avoided by Snell, not only because they were inhabited by unfriendly tribes, but also because they were notoriously unhealthy [III, 104 ; IV, 253–7].

The topographical survey resumed under Halpin from 1844 had been carried on with the utmost difficulty owing to the continued sickness of every member of the party, culminating in Halpin's death in November 1848. "The pestilential climate of Ganjam", had, in a few short years reduced "Captain Halpin, ... a fine powerful young man, ... to the last stages of decrepitude...from...repeated attacks of jungle fever"[5]. The topographical survey was then entrusted to Saxton who took it northward into the Tributary States of Orissa, where the party continued to be dogged by ill-health [167–9].

In the meantime Thorold Hill had put in hand the principal triangles of the East Coast series running southward from Calcutta through Midnapore to Orissa. The climate was very much the same as that which had played havoc with the South Parasnāth series under Alexander Boileau some ten years before [IV, 60, 175–6]. Hill's health gave way again, and after a year's sick leave he had to take furlough and resign from the survey [22–5]. He died in London in 1857.

The Surveyor General had warned Hill that the country was

notoriously unhealthy, and only capable of being traversed with impunity at particular seasons. ... If the establishment becomes affected by the miasma of those jungles all your future proceedings will be impeded. ... An immense quantity of valuable work may be executed by a judicious selection of proper time and season[6]. ...

[1] pamphlet price Rs. 1–10. [2] cf. the Assamese addiction to opium [454]; DDn. 705 (17) to DSG., 24–4–57. [3] DLR. 38/3 (117), DSG. to Pemberton, 20–3–58. [4] DDn. 652 (5), SG. to Mil. Dept., 6–10–60 (para 42). [5] DDn. 542 (272), SG. to Mil. Dept., 27–11–51, para 15. [6] DDn. 600 (194); SG. to Hill, 1–9–45.

Hill later comments that though the inhabitants generally shew no outward signs of suffering from sickness. ... Owners of estates and other wealthy individuals, however, migrate on the approach of the rainy season. In April 1849 the party was working near Gangra tower station on the right bank of the lowe r Hooghly [25]; and, writes Hill, all were in

high health and spirits when a sudden change of weather...prostrated the whole party. Marsh fever made its appearance and attacked everyone indiscriminately. The detached parties... all suffered about the same time, and...I have not been able to discover a single individual either among the public servants or camp followers who escaped this appalling pestilence.

On its first appearance I...resolved to move the camp to...a dry and commanding situation south of the Russulpoor River (or Hidgilee Creek) [IV, 188 ; pl. 3]. ... The distance, 12 miles, was with difficulty accomplished in 3 days, the worst cases...being transported in...Government dak boats. ... The change...was productive of no improvement, and...for some days not above 3 or 4 individuals out of 200 or 300 were able to cook their food. All my own private servants were ill and for 11 days...unable to do any work. ... Mr. Clarkson suffered very severely... as also did Mr. [W. R. N.] James...and Mr. Nield with all their servants and followers.

On the 17th April one camp follower died and...the condition of the camp became critical. To remain where we were was to endanger the lives of all. ... The surrounding country... afforded neither carts nor bullocks nor bearers. ... The only resource was water carriage. ... Nearly all the country boats had proceeded up the river to smoother water and safer harbour, and those that remained...obstinately refused to venture out into the Hooghly, maintaining that the weather was too boistrous. ...

No recourse was left but to apply for assistance from the dak boats at Kedgeree and one boat was lent me which carried away 15 sick. ... Fortunately the...surveying vessel Pilot, accompanied by the Grappler buoy vessel, visited that neighbourhood, and...Messrs. Bedford and Chalks, the commanders, ... most readily sent me their boats, and I was thus enabled to move the whole party to Natsal. ...

The bearers...were all sick, but with some difficulty I procured...a sufficient number from Contai to convey the great theodolite to Natsal. The climate of this place did not seem to be of advantage, consequently the camp was moved across the Hooghly to Sarisa which bears the name of being a healthy place, and here symptoms of improvement soon manifested themselves, and on the 20th May I was enabled to recommence operations[1].

Recovery was not maintained. The men could not stand up to the lightest of work, and the whole party had to beat a retreat to recess quarters at Midnapore [25]. A year later Hill took sick leave to sea leaving the party under charges of Clarkson. Again, in April 1850, they were forced to retreat, soaked with fever and overwhelmed by a ferocious tornado [25][2].

Saxton's topographical party fared no better. Soon after the start of his first season in charge near Cuttack. the whole party was down with fever. Out of the escort of 30, one died and 19 others were sent back sick to cantonments. Saxton himself was in bed for several weeks, and Howard reported that "all my lascars and private servants are laid up [168]". The Surveyor General had hoped so much from Saxton's appointment and lamented

this sad disaster. ... The pestilential character of the hill tracts...is well known. I have tried to evade the fatal effects...by limiting the field season to the shortest span consistent with some progress being made, but...every season the party has been driven back...at a very early period. The endemic disease peculiar to this tract, although more virulent at certain times than others, seems never to cease entirely[3].

He consulted the Commissioner who replied that Saxton's disasters

are...to be attributed mainly to his having entered a peculiarly unhealthy tract...before the water left by heavy and long-continued rain of the previous five months had dried up[4]. Had he waited until the beginning of January he would probably have experienced no sickness, and have been enabled to carry on his operations until the middle of April. It is a great mistake to enter these jungles too early [55]. ... I do not think they should be visited before the 15th December, ... and swampy tracts until the season is further advanced. ... As the dry season advances the country becomes healthier, and were it not for the heat and scarcity of water parties might remain cut until the rains with little risk[5].

[1] DDn. 508 (354), Hill to SG., 22–8–49. [2] DDn. 342 (37), SG. to Mil. Dept., 20–8–50, para 70. [3] DDn. 529 (38). SG. to Mil. Dept., 30–1–51. [4] NE. monsoon [IV, 251 n.3; V, 52 n.5, 467]. [5] DDn. 544 (506), Comnr. to SG., 2–6–51.

The Ganjam Collector was even more emphatic;

The earliest safe date for entering the jungles...would be about the 15th January—not earlier in the month—although this is only the *comparatively* safe season, for disastrous consequences have resulted...even at...the end of February. ... Security...cannot...be guaranteed at any time, but...danger is least...from the 15th January to the early part of May, or until the first falls of rain in that month. To remain later would be entirely unsafe.

Two methods of warding against...malaria have...been put into practice with entire, success. ... One is to have a fire kept alight all night near the head of the bed. The other which is safer, is to have thick curtains of chintz or some material equally stout about the bed [II, 362 n.7]. ... During the war in China [IV, 260] escape from fever...was attributed solely to never sleeping without the safeguard of curtains...put up over the sleeper. Precautions of this kind cannot probably be taken by the whole of any survey party[1].

The Political Agent in the Hill Tracts suggested further precautions and the restriction of a field season to about 3½ months [169, 367–8];

Each party should have a good apothecary...and an adequate supply of quinine, with a double supply of sick carriage and tents. The quinine should be freely distributed to all ranks as a preventative, and not merely "exhibited" when fever has prostrated the patient. ...

It is essential also that every man...be well tented and clothed and that during the cold weather they expose themselves as little as possible to the early morning dews or the evening damp. The hill people cautiously avoid such exposure, and are seen creeping out of their huts when the sun has dispelled the mist, and...lighting fires in the evening ere the sun sinks. ... The European officer and sub-assistant surveyors should carry...every reasonable comfort, and on the first symptoms of failing health should attack the medicine chest[2].

Saxton was glad of his later start the next season;

Though we have derived every benefit from prompt medical aid, ... the difference between this and last season is more shewn in the number of cases. ... I do not think this is to be attributed to a favourable season, as I learn that the Coast Series party has suffered much, and their work and mine joined at one extreme of my operations, and again on the other extreme the Khond Agency has had a most disastrous season. ... I...attribute our better fortune to having commenced later, and would urge that we be permitted to do so again. ... My own treatment of fever cases was quite successful, and the men apply to me with great confidence[3].

From 1852 the Directors sanctioned the posting of a European assistant surgeon each field season;

The result of the first year was disastrous [writes Saxton]. The appointed gentleman after his three months duty left with his health seriously shattered.

The following two years I fortunately secured the services of Dr. Shortt [171, 466][4] who retained his good health and who enjoyed the peculiar life so completely that he volunteered to join my camp for a second year. ... Dr. Shortt was a professional enthusiast. ... He everywhere...invited the natives to bring cases for medical and surgical treatment. In this way I witnessed many very interesting operations[5].

The party had a very bad season after Depree took over charge in 1856 [172–3] and, to give it a complete change and reinforce the topographical wing of the Kashmir survey, the Surveyor General suggested its move to Kashmir for the summer of 1857, but Dr. Gillies could not agree [173];

With the exception of Messrs. G. Howard and Atkinson, their present state of health will not admit of their undertaking so long a journey. ... Your health—being at present shattered by the fever from which you now suffer and the two attacks of dysentery you have had during the last three months, all doubtless produced by your very indefatigable...exertions...during the field season—precludes your services being disposed of in the manner contemplated.

Mr. R. Howard is old...and subject to piles, dispepsia, and cough, and is quite unequal to any unusual exertion. With great care...a year or two's work may be got out of him.

Mr. T. Claudius is suffering from fever which has been off and on during the last two months, and which has weakened him very much. ...

Mr. J. G. King contracted a hernia two months ago by an accident in the field where he has had measles, dysentery, and fever. The last complaint more or less continues. Vision weak, suffers from general debility.

Messrs. G. Howard and Atkinson have had fever but...are in perfect health at present[6].

[1] DDn. 544 (418), Collr. Vizagapatam to SG., 9–6–51. [2] DDn. 552 (5), Agent Hill Tracts to SG., 10–6–51. [3] DDn. 593 (247), Saxton to SG., 16–4–52. [4] John Shortt (1822–89); Mad. Med.; Asst. Surg. 40th MNI.; 1855–6 in med. ch. Nagpur Art., Kamptee; later, Supt. Vaccination Dept. Madras. [5] note by Saxton, 20–3–1900; family papers. [6] DDn. 657 (127), Gillies to Depree, 9–4–57.

Depree did not agree about himself, "I am now convalescent and...am ready... to start for Kashmir without delay", but the mutiny put a stop to all such plans.

Meanwhile the Coast Series experienced constant interruptions and seldom had a full season's work [26–8]. Peyton writes from Cuttack in April 1854 ;

Jungle fever breaking out in the camp, ... myself also having been one of the sufferers, I was necessitated to stop all field work and to take the party into quarters. The advance party under Mr. Clarkson fared no better, ... not a single man with him...escaped. ... Mr. Clarkson himself...had a severe attack of fever and was...very dangerously ill, but is now convalescent. ... The party is now fast recovering. Up to the 10th of March there was not a single case of sickness, but it was subsequent to this date that fever made its appearance. ... Mr. Blewitt also took ill at my last station...which obliged me to use the native sircar who writes English to register my observations. ... I was next attacked[1].

The following season was yet more unfortunate. Peyton spent December on azimuth observations on the sea coast near Balasore;

The healthy weather having by the 1st of January fairly established itself, the party now started for the hills. ... The season turned out an unusually sickly one, which by the beginning of March prostrated my whole party. ... After the observations at Calcutta Fort station it was found impracticable to continue. ... Mr. Rosenrode himself was one of the sufferers, and notwithstanding that his proximity to the coast enabled him...to recruit...by...the salubrious sea air, yet a second attempt to penetrate the hilly tract was attended with disastrous consequences...and obliged them to quit the field [27]. ...

Mr. Clarkson's party suffered severely, ... three of his men having died. ... Mr. Penny after only a fortnight's...was laid prostrate by fever which deprived me of his services for the rest of the field season. ... He has only lately recovered, ... and is even now a convalescent, the fever still...rendering him subject to its paroxysms during the periodic changes of the moon[2].

Strange took over charge from Peyton early in 1856 and urged Rossenrode to take ample time to shake off his fever before re-starting work;

Take quinine daily as a preventive measure. ... A two-grain dose per diem is likely to diminish considerably the virulence of a future attack, if it does not keep off the attack altogether. ... Administer small doses to your native establishment daily. ... This practise is recommended in the letter from the...Government of Bengal, ... and I have myself adopted it in my camp, as well as personally[3].

Though his first season's work lay in a reputedly healthy area ;

sickness set in steadily towards the end of January—never left the camp—and at times nearly disabled it. ... There were not more than four individuals, ... of whom I was one, who escaped fever, and the greater number had more than one attack. Every precaution was taken. ...

There is one thing...predisposes to fever, the food of the men. There are no buniahs' shops in the villages. ... The inhabitants do not keep their best rice in store. My camp was generally supplied with new rice of inferior quality, ... very prejudicial to health[4].

Though the Surveyor General thought that the quality of the food could hardy be a cause of the sickness—obviously malaria—affecting Europeans and Indians alike, he appointed a departmental committee to report on the following questions[5].

1st. Whether the insalubrity...is attributable to endemic miasmata or to the unwholesomeness of the food, ... or to both. ...

2nd. If...the evil...can be attributed to new rice or other unwholesome food. ...

3rd. What arrangements would be necessary for a special commissariat to supply...wholesome food during the field season. 4th. What would be the expense of such arrangements.

The Committee consulted Dr. Shortt, now at Kamptee [464], who thought that, the use of the new rice...does irritate the bowels, producing disrrhœa and flatulency, ... causing exhaustion and debility, and predisposing...endemic diseases. ... The term "new rice"...should be called "unboiled rice", ... "cutcha chawal". Paddy is generally boiled and dried in the sun previous to being husked, but in the jungles...it is husked without...boiling. In many parts of India no other than the unboiled rice is used. ...

An efficient commissariat with each survey party would be of decided advantage. A fortnight's supply should always be kept in reserve, ... to consist of boiled rice, ... curry stuff, salt, ghee, and oil. A butcher with each party would be a great acquisition, ... to...supply each man in camp with half a pound of meat daily. ... Each party should have one or two pakalees [45 n.6], with bullocks for supplying...water. Each pakhalee bag should have a layer

[1] DDn. 697 (37), to SG., 11–4–54. [2] DDn. 601 (99), to SG., 28–5–55. [3] ib. (150), 13–2–56.
[4] DDn. 698 (66), Strange to SG., 30–6–56. [5] DDn. 691 (94), SG. to Strange, 12–8–56.

of charcoal 3 inches deep at the bottom, and this should be renewed once every 2 or 3 days. ... The addition of alum would be an advantage where the water is very foul. ...

The best period for entering the jungle is from about the middle of December to the end of March. Any attempt to enter them earlier completely upsets the party by repeated attacks of fever arising from the vegetable and animal decomposition which is continually going on. ... The dense jungle and rank grass, etc., is moreover aggravated by the increased exhalations from damp ground and rivers that have overflowed their banks [456]. ...

It is prudent not to remain in any one village beyond 2 or 3 days, and...to avoid long marches; these should never exceed five or six miles. ...

The men should have sufficient clothing...[and] be furnished with straw to sleep on. ... They should be prohibited from sleeping in the open air, but where this is unavoidable large fires should be made and the men ordered to sleep in their vicinity. ... The men ought not to ...break ground ere daylight, and...[should] to partake of a newly cooked meal...as travelling with an empty stomach is likely to predispose the system to...disease. ...

Encamping grounds:— ... Avoid...jungle, swamps, and the neighbourhood of streams or rivers. ... Fires should be made around and in the camp. Water should...be dug for from the dry beds of...nullahs, and where this is not feasible, it should be boiled ere being used [460]. ...

Europeans:— ... Live well—be warmly clad with woollen socks, stout shoes or ankle boots—use of mosquito curtains at night—closing the tent purdahs at sunset—and avoid all exposure to night air—not to break ground before sunrise—and always to partake of food ere beginning the day's journey.

Though the mosquito's part in the spread of malaria was yet unknown, many of Dr. Shortt's rules would tend to baffle that noxious insect. The Committee recommended that pack bullocks should be used to transport grain and sufficient tents for all personnel. They considered that no prophylactic was more important than perfect shelter from night air. Each party should be allowed a qualified doctor[1].

Strange himself succumbed his second season. During March there was considerable sickness amongst the signal men and, on Girdbadi hill north of Berhampur, fever attacked the camp and Major Strange was one of the first victims. ... For eight days he was prostrated, but had to treat both himself and his men, for the native doctor lay sick...in the camp...six miles off. By degrees the sick were carried down the hill, and lastly Major Strange followed, ... only to find the camp there had been visited as severely as his own.

Out of 20 men composing the military guard only four remained free from fever, and nearly every man of the native establishment was either ill or had lately been so. ... Major Strange.. proceeded to Pooree for the benefit of sea air. ...

None of the cases proved fatal, but cholera attacked the party on its way from the field and carried off seven men. Major Strange described the fever as "productive of the utmost debility and depression of both mental and physical powers, and when once imbibed into the system...extremely difficult of expulsion, as it recurs at short intervals again and again, and deprives the patient at each recurrence more and more of the little strength that former attacks have left him". Only one man of the main camp escaped an attack of fever during this season[2].

Four months later Strange took long leave to the Nilgiri Hills.

Various sites were suggested as suitable for recess quarters. Meghasini Hill, about 40 miles west of Balasore, 3,823 feet above the sea [175],—Mahendra, 40 miles south of Berhampur—and Gali Parvathum, about 60 miles west of Waltair and over 4,000 feet above the sea. The last-named alone was at all suitable. It was visited by Strange in November 1859, and seriously considered by the Madras army as a sanatorium for troops, but Strange found it too distant and undeveloped for survey recess quarters[3].

[1] DDn. 697 (68), Comm. progs, 10–10–56. [2] *GTS.* VI & *Syn.* XIII (xxix—C). [3] DDn. 697 (114), Strange to SG., 24–11–59.

CHAPTER XXX

THE COUNTRY & ITS PEOPLE

Natural Obstacles — Destruction of Mark-stones — Disputes & Complaints — Armed Assaults — CIVIL AID : *British Districts — Indian States —* MUTINY OF 1857 : *General—Field Parties.*

POSSIBLY the most difficult part of India to survey, with particular reference to the Great Trigonometrical Survey in the middle nineteenth century, was the line of the East Coast series breaking out from the densely populated suburbs of Calcutta, and working south through the interminable swamps and closely-wooded flats of Orissa, teeming with malaria, and with a minimum of commanding or recognizable features—too water-logged and saturated with fever to allow of work till well into January—and with atmosphere choked with dust and haze by the middle of March. A country blessed with two monsoons, a double dose of fruitful, frustrating, rain ; working season cut down to a matter of ten or twelve weeks. That was the east coast [23–4, 462–3]—and was the west coast so very much easier ? North Konkan—Rājpipla—Gujarāt, where Rivers was defeated two consecutive seasons by fever and impervious atmosphers and where Haig in 1860–1 "by no means got off scot-free" [55, 460–1]. At Kesarwa

> no less than 60 per cent of his men were on the sick list, and by the close of the season there was hardly a native in the party who had not at one time or another been a sufferer. ... There is a local proverb...to the effect that the Dang should be feared like a musket ball[1].

The jungle, swamps, and forests of Lower Assam were relieved by occasional isolated hills, but the continuous belt of *tarai* forest stretching along the foot of the Himālaya from North Bengal through Bihār and Oudh to Rohilkhand made the North-East longitudinal series a formidable project, that was perhaps mastered the more readily because it was engaged in piecemeal fashion by no fewer than seven different field survey parties [17–9]. The Great Longitudinal series, forcing its way across the rough Aravalli Hills and the mirage-haunted sandhills of the "little desert", and skirting the salt-pans of the Rann of Cutch, calling for untiring energy and patience, and the Great Indus series with its long sequence of close-set towers running up the dreary sands of the Indus valley, were not so heart-breaking as the humid, fever-ridden, featureless, wooded plains and undulating swells of the East Coast where practically every member of the party, season after season, from the officer-in-charge in his observatory tent to the four-rupee *khalāsi* cutting a line or humping a load, might expect to be shivering with pestilential ague for the greater part of the season [462–6]. The greatest obstacle was the malaria, and the complete ignorance of its cause or cure. Other troubles and difficulties were but pinpricks to stimulate the surveyor's professional zeal.

The mountain steeps and precipices—the snow and ice, the baffling clouds—the shortage of provisions and absence of fuel—of the high Himālaya were challenges to the spirit of adventure on a different plane to the horrors of disease.

Though fellow denizens of the forests, the surveyors had few contacts with the wild beasts. Peyton had an affair with a leopard [15], and Thorold Hill kept a "heavy battery ready" for buffalo and deer along the coast. The defenceless Survey followers had, however, a wholesome fear of lonely paths, and had little chance alone with tiger or bear. Clarkson, on the Maluncha series, had a man

[1] *GTS.* XIV & *Syn.* XXXII (xii—H).

...killed by a tiger about 100 yards on the road leading to the station. This poor man happened to be Mr. Rossenrode's sais who was early in the morning taking out his horse for exercise, and though he had received due warning from the horse, who pricked up his ears and kept snorting for a considerable time, with his eyes rivetted to where the tiger lay concealed, yet he seemed not to be mindful of the danger at hand, but mistook this forewarning for the bad habit the animal had...of...being obstinate when separated from the other mare.

He continued to urge the animal forward, when all on a sudden as she reached the spot she bolted away and escaped from her keeper. The tiger at this moment sprung on the sais whom he killed and dragged a good way up the hill before he was rescued from the beast. He was a corpse, and the blood was flowing from the wounds which the tiger was seen lapping when assistance arrived[1].

Hill describes the working of the triangles down the coast from Calcutta ;

The grand obstruction...has been the climate, with the mists and fogs rising from the low marshy lands, and blown up from the sea. Next...must rank the innumerable rivers, muddy creeks, nullahs, and canals, which like a network intersect the whole of the...country between Tumlook and Balasore. ... The surface of the country is a dead flat, densely covered with fruit trees of various kinds, ... thickly studded with populous villages, and intersected by almost innumerable muddy creeks and watercourses affected by the tide, and in many parts swampy or inundated during nearly three parts of the year [23–4][2].

There were storms and tornados on the coast ; there were long delays from impenetrable haze [25, 29].

Just as the Bombay party failed in its first attempt through the North Konkan [54–5], so also the Assam party had to be switched to the more favourable country of the Eastern Frontier series [31–2]. Nicolson found the country all paddy cultivation, which, having been submerged during the rains, was up to the middle of January still under water, and only commenced drying after that period, when the inhabitants commence preparing their fields, in which heaps of manure are piled up everywhere at distances of a few yards and set fire to, from which a thick smoke is produced that, settling upon the surface of damp earth, caused the objects to dance about like an ignis fatuus, so that trustworthy observations become quite impossible[3].

Further up the Brahmaputra valley, east of Dhubri,

a portion of the country south of the river about 8 or 9 miles in breadth is composed of chur lands [sandbanks], some parts cultivated, and other parts covered with high grass and infested with wild beasts. The rest of the flat lands up to the hills is covered with forest with only patches here and there cleared for paddy cultivation. There are no high roads, but intricate and winding footpaths, crossed by numerous streams which are fordable during the dry season, but with some difficulty, being full of quagmire. An elephant will sometimes sink up to its chest in one of these and throw all its load into the water. After April even these ...communications cease, and the inhabitants...carry on...by means of canoes. ...

The country to the north of the river has many insulated hills, ... but being surrounded by forest they are also difficult of approach. The intervening flat lands, particularly near the banks of the river, are well cultivated, and...no difficulty is experienced in procuring supplies, ... but travelling is difficult as there are numerous rivers to be crossed, and many swamps —the hotbeds of disease and malaria—to be avoided[4].

Further east beyond Gauhāti, writes Beverley,

the hills are covered with the thickest and heaviest tree...jungle, and...very thinly populated indeed, and the villages...inhabited by Cossyahs and Mikirs are few and far apart, frequently eight and ten miles apart, while each village has only from three to twelve families, rarely the latter number. The inhabitants are also a very timid race and, never having seen Europeans before, as soon as they hear of one's arrival whole villages desert, and go to their fields of cultivation at distances of miles, where they remain for days together. ...

Elephant carriage, so very requisite for travelling, ... must now be almost entirely dispensed with within the hills, as it is impossible for them to march with any loads whatever in the interior. ... Coolies must generally be resorted to as the only mode of carriage practicable in the hills. ... They are decidedly adverse to carrying loads. ... After 3 or 4 days delay 20 or 30 coolies only could be procured with the greatest difficulty, who were from the light loads they carry insufficient even for my small party[5].

[1] DDn. 502 (24), Clarkson to SG., 24-2-44. [2] DDn. 508 (281), Hill to SG., 5-7-43. [3] DDn. 702 (44), Nicolson to SG., 14-11-56. [4] ib. (30), Nicolson to SG., 16-3-56. [5] DDn. 703 (344), to Lane, 4-6-59.

The preservation of the marks establishing the exact position of the trigonometrical stations was of the highest importance [III, 245, 415 ; IV, 86], and it was essential that they should remain undisturbed throughout the observations for which they were laid down, and these observations might extend over several seasons. The disturbance of even a single mark would entail re-observation at several stations, and might seriously affect the connection of a chain of triangles or a local survey many years later [112–3].

It was the regular practice to entrust the protection of field stations and observatories to local officials or landowners [113], who sometimes asked to be relieved of the trust. In 1852 the Bengal Government asked if they might dismantle the two base-line towers on the Barrackpore road. The Deputy Surveyor General replied that they should most certainly be left standing as they would be required for the start of a chain of triangles running to the east [32 ; pl. 4]. The towers are standing to this day.

In 1847 the Political Agent asked whether the Nawāb of Tank might purchase the small field observatory at Kaliānpur near Sironj ;

Although the amil, or manager, may have been willing to give seven hundred rupees for the buildings, ... the Nawab himself...said that he would only give five hundred. ... A guard of six sepoys is maintained by the Nawab for the care of the buildings, and...he is further at some annual expense for renewals and repair. ... The Nawab wished to purchase the buildings in order that the expense of guarding them might be saved.

His Highness also doubtless wishes to get rid of *our* right of proprietorship[1].

The Surveyor General urged the professional importance of preserving the marks intact, and the undesirability of surrendering the interests of the Survey ;

Kalianpur is the central limit of the northern sections of the Great Indian Arc, ... the point of origin or reference for the accurate geography of all northern India [124–5]. ... In October 1848, I hope to...commence upon the Greater Longitudinal series...to extend from Sironj to Sinde...which will emanate from the station of Kalianpur [37]. There will be no immediate probability that the station...will...be again visited for many years, but the preservation of the mark will always be a desideratum. ...

The buildings consist of the observatory and the platform, which lie a few yards...of each other. The former was used for observing the celestial amplitude [IV, 98–101], and the latter...at which the terrestial observations were taken...will again...be occupied. ...

The present arrangements should be continued till the close of...1848, when the party... which will then visit the station will be able...to close up the door of the observatory with masonry. The guard may then be safely removed and the building be left to protect itself. ... If these buildings were sold to His Highness the Nawab...it would be difficult to revisit the spot for survey purposes[2].

Renny duly closed up the building after completing his observations in 1849, but the observatory was no longer standing fifty years later[3] [113].

British troops had little respect for survey marks, and in 1853 Robinson reports from Rawalpindi District the total destruction of

the G.T. Survey mark upon the Mankiala top. In consequence of some European soldiers having injured the mark on a former occasion, I procured from the Brigadier commanding a district order...that soldiers or others...should not meddle with the survey platforms or instruments. ... Notwithstanding this the mark has been utterly destroyed[4].

In 1851, Logan had obtained an assurance of the future preservation of the survey station "on the Murree Peak, together with a space extending 10 yards in all directions from the platform and also a right of way from the high road"[5]. Seven years later Robinson reported the destruction of platform and mark ;

On Saturday last I required to use the station for...correcting some measurements connected with the height of an important Gully in this neighbourhood[6], and...first learned that the mark had been utterly destroyed. ... The authorities...fixed upon the Murree Knoll as the site for a blockhouse...for the defence of that end of the station, and...the officiating Executive Officer ...had cleared away the summit of the Knoll, and with it all signs of our station. ...

[1] DDn. 463 (521–4), FA. Bhopal to Resdt., Indore, 22–7–47. [2] DDn. 464 (277–9), SG. to AOG., 2–9–47. [3] *GTS. Trig.*, 54 H. [4] DDn. 593 (437), to SG., July, 1853. [5] DDn. 612 (25), Comnr. Jhelum to Logan, 31–12–51. [6] *Gali* = neck of hill occupied by buildings in Murree Hills.

Considering that the whole summit of the Knoll is registered as the estate of the Gt. Trigl. Survey—that the Knoll is called Observatory Hill—that the station has been more or less in use every recess...for the last seven years, ... I am surprised that neither Captain Walker nor myself were warned that the site was required for other purposes[1].

In 1855, Tennant expressed anxiety lest the railway engineers might destroy his observatory and survey marks on Bath Island at Karāchi [130]. The Government of India obtained an assurance from Bombay that

measures have already been taken to ensure the preservation of all the marks of the Great Trigonometrical Survey in Sind, to prevent any railway operation in the neighbourhood of the observatory which could interfere with the delicate observations there conducted, and generally guard from injury and disturbance every spot connected with...the surveys. ...

The course of the railway was yet undetermined; ... nothing has been done beyond surveying several lines, the flags posted for one of which near Bath Island drew the attention of Lieutenant Tennant. ... Mr. Frere assures Government that whenever the selection of the line...is to be decided, every care will be taken to avoid interfering with records of so much importance to science as those of the Great Trigonometrical Survey[2].

During season 1853–4, Nasmyth found that his station marks at four stations near Bhaunagar in east Kāthiāwār had been tampered with, though in each case the lower mark-stone had been left untouched. At Trimbak station "among the Kokra Hills, the upper mark has again as dextrously as before been cut out of the stone". The Political Officer suggested that the damage might have been the work of a wandering madman, to which Nasmyth replied that it was most unlikely that a madman would of himself have stumbled upon the most important stone of the platform, when that stone was in no case sufficiently marked to attract notice—that a madman would guess the existence of a station on the wild summit of the Kokra Hills, or on the distant peak of Chambadri—would wander to these places to repeat mischief which could afford him no gratification—or would have patience and perservance to obliterate the mark from the stone[3].

He suggested that the outrage had been committed by local people, who feared that the survey operations foreshadowed "the establishment of a sanatorium on their sacred mountain". The Surveyor General did not wish to press the complaint, and suggested that the damage might have been done "by mischievous cowherds. These...are often mere children, and like all idle people are very mischievous" [262][4]. Three years later similar damage was done at three stations in Cutch, more than 150 miles from Bhaunagar, which might support the Surveyor General's view of childish mischief, though Nasmyth strongly suspected religious fanatics [472–3].

... Sandes tells a story of a 20th century surveyor who found a G.T.S. station of Bihār preserved as a shrine with guardian devotee, who allowed him to open it up and shew the survey mark cut on the solid rock[5].

DISPUTES & COMPLAINTS

With the numerous survey detachments working through the wide areas of India, with diverse communities of race and religion, and numberless administrative sub-divisions, it is not surprising that there should have been occasional misunderstandings and clashes [II, 363–72; III, 407–15; IV, 160–3]. However careful the survey officer might be to keep in touch with administrative and political officers, and to obtain all official authority, many of his assistants were young and inexperienced, and impatient of delays, and many local villagers and headman were jealous and suspicious of the activities of strange intruders who made insistent demands for supplies and labour, and wandered wherever they pleased regardless of local sentiment [IV 151; V, 477]. Trouble was more frequently experienced in the territories of independent or protected states than in regulation British districts.

[1] DDn. 731 (9), to SG., 29–9–56. [2] Henry Bartle Edw. Frere (1815–84), BO. CS.; Ch. Comnr. in Sind, 1850–9; DDn. 641 (208), Bo. Govt. to Govt. of India, 5–10–55. [3] DDn. 719 (33), Nasmyth to Mgte. Ahmedābād, 1854. [4] DDn. 613 (139), Nasmyth to SG., 18–6–54; reply DDn. 592 (91), 11–7–54. [5] Sandes, II (206).

John Lawrence, when Commissioner of the Trans-Sutlej States, complained of the conduct of some of Du Vernet's assistants working in Mandi State, in the hills beyond the Sutlej ;

I have received a letter from the Raja of Mundee complaining that the subordinates of your establishment have injured the shrine of a Hindoo deity in his territory. ...

The Raja is an independent chief, and on your arrival in his territory you should have paid him the compliment of addressing him by letter, and in the event of...any buildings... removed, or erected, the work should have been done by his permission and through his officials. ...

I have no doubt that the Raja has much exaggerated the injury, but it is not the less necessary that you should impress on all the subordinates...to be extremely cautious in interfering with any place of worship. ... In your communications with him you should use the usual courteous style of addressing a native chief, and be particular to omit none of his titles [480][1].

John Dyer, the assistant working in Mandi State [202], explained that he was selecting stations for the minor triangulation of the North-West Himalaya series. One of the stations selected was situated upon a high hill called Shikari Dibi, within 8 or 10 feet of a few stones which I suppose to be the shrine referred to. Having myself superintended the erection of the staff at the above station, I have no hesitation in intimating that the shrine...was not desecrated by me or any of the...establishment with me. ... I was not more than 48 hours within the Rajah of Mandi's territory, and...the station of Shikari Dibi is in a wild and thinly populated part of the country, about 5 miles from the boundary[2].

The Surveyor General replied to the Commissioner that although Dyer has not been more than two years in India, still he is perfectly acquainted with the propriety and policy of respecting the prejudices of the natives, and his conduct has always been conciliatory and just towards them. ... Mr. Dyer denies having desecrated this shrine, and...in common with the rest of my subordinates is fully imbued with the desire of maintaining the credit and honour of the Department. ...

Making every allowance for the Rajah's apprehensions, ... I have addressed a kareeta to His Highness in which I have explained that the objects of the survey have no connection either with the selection of cantonments or with the revenue of the country, but that our intention is merely to make a pictorial representation of his territories for the improvement of our general geographical knowledge. ... The more he is disposed to facilitate its progress...the more speedily will the surveyors finish the work and leave his country[3].

A friendly reply was returned through the Commissioner, and Du Vernet was authorised to carry on the survey.

A year later, Dyer's work in the Simla Hill States had to be suspended owing to trouble with villagers. Du Vernet reporting that "since leaving Pathar Nala" he has been unable to procure tahsil chaprasis, and that in consequence of his party endeavouring to obtain rations for themselves...they got into a dispute...which ended in the villagers making an assault on his people—that several of the most active he forwarded to the tehsildar with a complaint, and that in consequence a counter-accusation was got up by the villagers, on which...one of the barkandazes...was seized and placed in confinement in irons[4].

He reported later that

Messrs. Dyer and Talbot [were] brought into court [and] the latter bound over on security. ... Mr. Dyer represents that he would not have been subjected to the assault had he been furnished with a sepoy guard. I have furnished Messrs. Mulheran and Burt with a guard each from my detachment. ... An individual keeping to the high road may travel without a guard, but a surveyor cannot do his duty without an escort of some sort[5].

The Surveyor General wrote later to the Political Officer ;

The case seems to wear a very serious complexion, and I regret that such raw inexperienced youths were deputed on this work. Both Mr. Dyer and Mr. Talbot are mere lads, infants in the eye of the law. The former who was educated in England has not been more than three years in India ; the latter only left school a year ago. ... I am very sensible of the importance of maintaining a rigorous discipline in this department. ...

... It was out of my power to spare any qualified persons of more mature age ; I regret much to learn that any disturbance should have occurred. ... He himself [Dyer] seems not to have mixed in it. ... I observe...that Mr. Dyer failed to report his arrival to you, and that he did not furnish you with detailed information of the movements he was about to make. The

[1] DDn. 465 (415–7), 28–11–48. [2] DDn. 606 (30), Dyer to Du Vernet, 30–12–48. [3] DDn. 466 (181–3), 4–1–49. [4] DDn. 525 (194), to SG., 20–11–49. [5] ib. (198), to SG., Feb. 1850.

former omission on his part was improper, but the latter information is seldom in the power of a trigonometrical surveyor to supply as his progress depends on the weather. He may be detained for days by mist, and when fine weather sets in his progress is often very rapid[1].

The complaint that Du Vernet's party had violated the sacred hill of Trikota, or "Tirebtar" within Jammu territory was particularly unfortunate, and involved the loss of a full month of the field season [35–6]. The Surveyor General had been at pains to obtain the Māharājah's official permission for taking the principal triangles of the Himālayan longitudinal series across the Jammu boundaries, and was much distressed to learn in April 1850 of a newspaper report from Lahore that survey *chaprāsis* "have been dishonouring a temple of Devee on the mountain of Turhutta". He ordered Du Vernet to withdraw his party "with the least practicable delay" but at the same time to collect "sufficient information for a full report. ... Although I have no doubt that the complaint...is exaggerated, and perhaps false, still there must have been considerable want of tact and conciliation in the management of the matter"[2].

To the authorities at Lahore he pointed out the need for access to hill tops;

As the origin of the affair seems to have been the visiting by Europeans of a hill on which a temple stands, it frequently happens...that a particular hill must at all costs be selected to obtain symmetrical triangles. ... When a hill is preoccupied by a temple, it is always a matter of delicacy and address to obtain access, but a conciliatory line...has never hitherto failed of success, even in parts of the country where the people are most particular. ...

Colonel Lambton in southern India was frequently obliged to place his theodolite on the tops of temples [II, 241, 244]. In the case, however, of temples on hills there is seldom any necessity for occupying the building, as the station may generally be fixed on one side. ... Such hills are never visited but with extreme reluctance. ...

It was not...without much hesitation...that I proposed...a series of principal triangulation through the territories of His Highness the Maharaja Goolab Singh. ... On purely professional grounds the plan adopted was decidedly the most accurate mode of connecting the hill provinces beyond the Jhelum. ... The connection might certainly have been formed by...carrying it along the plains within our own territory, but this plan would neither have been so accurate nor so rapid as the other [220]. ...

It was a matter of urgent importance to fix a sufficient number of points in the Punjab before the commencement of the revenue surveys [37, 273]. ...

I am unwilling to incur the responsibility of allowing the work to proceed further without the entire concurrence of the Board. ... The continuance of the survey party in the dominions of Jammoo may produce political misunderstanding[3].

The Māharāja responded most courteously that he had heard that the hilltop had been violated by survey followers, but that he had been "satisfied that the temple was not desecrated intentionally. The men were not aware of its sacred character. I...thought it needless to write...on the subject"[4].

Du Vernet reported that he had sent an assistant to make enquiries on the spot and make friendly contact with the "head brahman", and was satisfied that the survey followers, all Hindus, would never have treated a sacred place with disrespect [35–6]. When Logan took over charge of the triangulation the following year he succeeded in extending the principal triangles without occupying Trikota;

Serious objections having been made...to the occupation of the summit of the Trikota mountain...I deemed it desirable to proceed...to the neighbourhood of the sacred mountain and endeavour to find some other point that could be substituted for it. ... Difficulty...experienced in selecting a station in advance of Samnabhanj...obliged me to devote 14 days to an examination of the country before I found a suitable point for extending the series westward [36–7][5].

Nasmyth suspected that the damage to his station marks at Trimbak and elsewhere [470] had been carried out or inspired by followers of the *Shravak* community, who had protested to the Political Agent against the occupation of their sacred hill Shetrunja that lay 20 miles to the south-west of Trimbak[6]. They were followers of the Jain religion, and...have their most holy place, ... commonly known by the name of Shutroonjaya mountain...in the vicinity of Politana in the province of Kathiawar. It

[1] DDn. 543 (24), to Supt. Simla States, 4–3–50. [2] DDn. 493 (294), 23–4–50. [3] DDn. 542 (14), 24–4–50. [4] DDn. 526 (278–9), from HH. to Bd. of Admin., 8–5–50. [5] *DDn. 503* (235), to SG., 11–7–51. [6] 1,971 ft. above sea; nr. Palitana, 25 m. sw. of Bhaunagar; r. *Kathiāwār Gaz.* (47–8).

is held as holy and as sacred by the Jains as is Jerusalem held by the Christians and Mecca by the Mohammedans. Upon this mountain there are numerous...temples erected...by the Shrawicks. ... They ascend it only to offer their prayers, ... and...nobody, not even themselves, are allowed to stay there between sunset and sunrise. ...

A few days ago one Mr. Smith [Nasmyth] a gentleman belonging to the trigonometrical surveying department pitched a tent on the...holy mountain, ... and stayed there three or four whole days, ... moving in the sacred place with his shoes on, eating animal food, etc. The... said gentleman has obtained an order...to build a tower for observations...near a temple. ...

Your...memorialists beg...that the proposed tower may be prevented from being erected, ... and that in future no European gentleman may interfere with the most holy nountain[1].

Nasmyth replied that he had been very careful to obtain permission from the Jains before setting up his station, and that he had complied with all their conditions, sleeping in a small room set aside for muslim guards and having his food cooked at the bottom of the hill. In spite of this he was continually pried upon whilst carrying on his observations which he had, however, managed to complete. The Political Agent was able to pacify the *Shravak*, leaders and pointed out that not only did the Jains maintain a strong guard of Muhammadans at the temples, but that the grass on the hill was regularly cut by the Bhils[2].

ARMED ASSAULTS

In some parts of the country it was necessary for surveyors to have small guards, either regular sepoys or armed civilian *barkandāz*, that were specially desirable for the protection of signallers or messengers with post or treasure [376–8]. Du Vernet reports an incident in Oudh where there was little control over outlying areas.

A guard consisting of a havildar and 5 barkandazes accompanied by 4 lascars proceeding from my camp to escort pay from the Residency at Lucknow was attacked at Bilgain by the zemindar of that place with about two hundred of his retainers, armed with clubs, swords, etc., he and his son being the principal actors. ...

It appears that a barkandaz was siezed by a dog of the zemindar's on passing his door, that he beat it off with a stick, and that it ran howling into the house, whence the zemindar's son...came out, and calling men to his assistance siezed and beat the men most severely. The father...and son...being assisted by near two hundred men, it was impossible for the guard, armed with swords, to defend themselves. ... The former siezed them, having administered punishment, ... bound them, and then finding by their breastplates that they were the Hon'ble Company's servants, they became alarmed and consulted...whether it were not better to kill the men and destroy their breastplates. ... After holding the party close prisoners two days, ... and having threatened, passing swords over their necks and drawing their bows at them, they on the third day set them loose, having first extorted a raj-i-namah, which appears—according to the usages of Oude—sufficient to protect them [376][3].

Such incidents were more frequent in thickly populated districts than in frontier areas where people were, on the whole, quite friendly if tactfully dealt with. Waugh records his meeting with the frontier people between Sikkim and Nepāl [83];

After obtaining the consent of the Bengal Government it was found...that the Nepalese had taken alarm, for as my station...stood exactly on the border line of the two States it was deemed an encroachment, and the consent of the Nepalese Government became necessary.

This Dr. Campbell was kind enough to arrange for me, ... but when my advance party under Mr. Lawrence at length started with the sanction of the Nepalese Government, they were opposed by a large party of the Sikkim people. After a long parley this obstacle was evaded by taking a more circuitous route, and as Dr. Campbell...soon succeeded in removing their repugnance, my party at length occupied the desired position at Tonglo. ...

During my encampment there all travellers were hospitably entertained, and every effort made to promote a friendly feeling with the tribes. Several spys also came from the Nepal side. These were kindly received ; the instruments were shewn to them, and every explanation afforded. ... After this no opposition was offered[4].

[1] DDn. 613 (108), from Shravack inhabitants of Gujarāt to BO. Govt., 4–7–53. [2] DDn. 613 (108), Nasmyth to PA 2–8–53 ; 613 (109), PA. to BO. Govt., 4–8–53. [3] DDn. 436 (25–7), Du Vernet to Lucknow Resdt., 8–3–44. [4] DDn. 462 (265–307), SG. to Mil. Dept., 15–1–49.

In November 1849 Du Vernet's party on the North-West longitudinal series was caught up by the local risings which accompanied the outbreak of the second Sikh War [35], and he reported on 30th November that

the whole valley of the Soan being in a state of insurrection, and held by parties of the enemy, I have retired to Kalka. ... The insurrection extended the whole length of the valley on the 26th, and two of my parties of lampmen going to Baraol[1] and Bonabola never reached their destination. Mr. Blewitt was at Bonabola and marched for Rohan...on the 26th; should necessity require he will retire to Ludiana. Mr. C. Olliver...between Amb and Mokhaira being off the high road has probably escaped. ... Mr. Mulheran at Bilaspur I have directed come within to the Company's boundary, and Mr. Keelan, I believe, is at...Saika Hati[2].

As a matter of fact Olliver was in the thick of the trouble and he wrote to the Surveyor General that while camped at the village of Amoha, on the 25th

my camp...was attacked by a party of Umed Sing's horse; my property with that of the men plundered, and myself made a prisoner and sent on to the village of Krot, the seat of the Rajah. On the 1st instant I was brought on to Amb which on the morning of the 2nd was taken by the British troops and myself set at liberty.

The 12-inch theodolite...has...been seriously injured; its level (vertical) is broken, and the limb...bent. Its stand too is missing. Two heliotropes and a telescope had previously been detached by me, and...the men to whom they had been given started for Dehra...on the evening I was made prisoner. Having now no tents or clothing, in fact, having nothing whatever excepting two logbooks and the clothes I have on, I propose starting for Dehra to refit myself. ... Being ignorant of Captain Du Vernet's address, I...write to you direct[3].

To Du Vernet he gives further details;

At the village of Amoha in the Jaswan valley my camp was suddenly attacked by about 100 horsemen and foot-soldiers, all well armed with swords and matchlocks; myself made a prisoner, and my escort...of 1 naik and 4 sepoys of the Sirmoor Battalion...stripped of everything; their arms and accoutrements...all taken, ... and they themselves maltreated. ...

My camp was pitched far from the water, and all the people...were obliged to cook their victuals at some distance from the tents. ... The sepoys had barely time to lay down their cooking utensils when they found themselves surrounded, and without even a chance of defending themselves. ... I desired the naik to get his four men together and escape under cover of darkness to Hoshiarpur and report himself to the Officer Commanding there[4].

The party resumed work towards the end of January, and in due course Government granted compensation for the losses incurred—Rs. 817-1-10 to the Surveyor General for Government property and Rs. 800 to Olliver for personal losses[5] [413].

During the four years of his survey of Peshāwar [214-7] James Walker avoided all conflict with the border tribes, tactfully retreating or abandoning forward plans whenever opposition threatened. His work was, writes the Surveyor General, of a most interesting description, and attended with great risk. He had frequently to obtain access to his stations by causing diversions to draw off attention for a limited time, during which he had to take his observations, and then ride hard for life. By admirable tact and management as well as cultivating friendly relations, ... he succeeded in conducting his work without collision, and with only a single accident, on which occasion his native groom was killed[6].

Walker himself tells of working near

the tribe of Affreedie who occupy the centre and western portions of the same ranges. ... To go into their country excepting by force is never possible for a European, and is at all time dangerous for a native. ... It is dangerous to be near them. ... I should not have been justified in remaining longer than absolutely necessary in such a district[7].

The valley of Ranizai was reconnoitred with considerable difficulty and danger. Its inhabitants were most jealous of the approach of a European. ... The survey had therefore to be made cautiously from distant stations, one of which was...a mound in the plains east of Shakote. At this mound some risk was incurred, for the Ranizai's supported by their neighbours the Swattees, turned out in considerable force to oppose the advance of the Feringhis into their valley, and by opening a matchlock fire upon the party brought the reconnaissance to an abrupt termination[8].

[1] 10 m. NW. of Rūpar. [2] DDn. 606 (20), to SG. 30-11-48. [3] DDn. 606 (22), 4-12-48. [4] DDn. 525 (52), 16-12-48. [5] DDn. 541 (23-4), go. in c. to Ch. Comnr. 2-4-49; 493 (184), SG. to Du Vernet, 16-4-49. [6] DDn. 549 (63), to Mil. Dept., 19-9-53. [7] DDn. 593 (301), to SG., 28-10-52. [8] DDn. 593 (343), 11-9-54 (para 24).

The Kookikheyl and Bussikheyl Affreedies are respectively located near the mouths of the Khyber and Kohat passes. ... There is little to show in maps of such a country, and...that little was obtained with considerable difficulty. ... The operations of the surveyor were watched with great jealousy, and on three occasions had to be terminated abruptly because the Affreedies turned out in numbers and opposed all further advance into their country[1].

In February 1852, William James took up a line of triangles to cross the Indus and connect up Walker's survey [37, 215], and narrates that he had been advised to proceed direct to the neighbourhood of Kapoor Gurhi in Eusofzahi to have an interview with Captain Lumsden, the Depy. Commissioner of that district, before commencing the work[2].

An escort, ... 35 foot soldiers of the Guide Corps and 6 local horsemen, had been appointed to my party with which I proceeded to Toroo about 6 miles west of Kapoor Gurhi, and waited upon Captn. Lumsden. ... I was informed by him that...the only place at which he apprehended danger...was...in the neighbourhood of Tukti Bahi. ...

As it was desirable to me to visit this point before going further, and the escort with me being...too small for the protection of my party, ... Captn. L....ordered a troop of the Guide Corps...to move out to Goojurgirhi, the village nearest to Tukti Bahi. The rise of a mountain stream near which Captn. L. as well as myself were pitched that night...rendered it impracticable for me to proceed the next day to Goojurgurhi, and...induced me to march on to Peshawar, merely leaving a party with a heliotrope to proceed to Tukti Bahi. ...

A rumour having got abroad of a sahib engaged on some important duty being on a visit to Tukti Bahi, a party of the Swat horsemen, ... about 120, came down by night on the troop. ... This party came up between one and two o'clock in the morning, prepared with stratagem as well as force, for being challenged by the sentry the men in advance replied "Sahib" and "Come on". The resildar with the troop, happening to be awake at the time, came out, as he supposed, to receive me, but was quickly undeceived on perceiving the lighted matches of the advancing body, being well aware that no British troops betrayed their presence thus. He...rushed back to seize his arms giving the alarm.

The few that were awake had to make a desperate stand against the enemy who, firing a volley directed principally at the risaldar's tent, rode into the camp cutting about on all sides. The affray lasted till daybreak, but owing to the darkness the only casualties...on the side of the troop were...three sowars and five syces. Those on the side of the enemy could not be ascertained, ... [they] having succeeded in carrying off their dead and wounded[3].

On hearing of this incident Government ordered the suspension of the triangulation, but by the time the orders arrived, James had closed his connection.

On the Derajāt survey, 1855–60, which covered the strip of plain between the right bank of the Indus and the tribal hills to the west running south from Dera Ismail Khān, Johnstone was equally successful in surveying the whole line of frontier without serious collision with the tribes [218–9].

Godwin Austen had a narrow escape from a vicious assault when surveying beyond Jammu in 1858. His area was perfectly quiet and the people generally friendly, but there was a brahman village, Siri, which lay under official disgrace;

If Austen had known [writes Montgomerie] what sort of village he had...to deal with, he would have avoided all trouble by not going into the place himself. He thought it was like any other. I think the survey is generally popular with the people ; they like our regular payments. Wherever we go they seem glad to hear of its progress. It is only some of the petty officials...who occasionally...make difficulties. ... The district in which Austen was working... has been visited by several surveyors, and Lieut. Austen worked there for a short time, and so did myself, and I feel sure that the attack was an exceptional show of feeling[4].

An enquiry was held at the request of the Māhārāja by the Deputy Commissioner of Siālkot, who found that on the 2nd November 1858 Lieutenant Austen entered the village of Siri with two followers...a private servant and...a guide, and asked the village headman, Ram Kishen, for a guide to show the way to Adumpore. The headman refused, and...abused the officer. ... He immediately afterwards called on the inhabitants to expel Lieutenant Austen from the village. A scuffle ensued in which Lieutenant Austen was severely beaten, and left senseless on the ground at some distance from Siri. ...

The five villagers who were sent in to Sialkote by the Maharaja to answer this enquiry... deny all knowledge of the matter, but Lieut. Austen identified Ram Kishen as the man whom

[1] DDn. 593 (343), 11-9-54 para 31. [2] Harry Burnett Lumsden (1821–96) of the Guides; *DNB.*; *DIB.*; bro. to Peter [225]. [3] ib. (357), Report by W. H. N. James, 20–3–52. [4] DDn. 716 (367), TGM. to Punjab Govt., 17–12–58.

he first addressed, who refused to render aid, and who incited the villagers to attack the English officer. ... As the villagers themselves render no explanation, the Chief Commissioner finds it difficult to decide as to the real circumstances. ... There is no doubt, however, that Lieutenant Austen was grievously maltreated, and considering that the Maharaja has already caused the village of Siri to be destroyed, ... the Chief Commissioner deems that it will suffice to send the prisoners back to Jummoo with a recommendation...that Ram Kishen be imprisoned for one year, and...[two others] for six months each.

The Chief Commissioner further asked that the Māhārāja should depute "an intelligent native officer with two or three sepoys to accompany Lieutenant Austen or any other officer who may be surveying His Highness's Dominions" and also desired that requests for aid should invariably be made through the Māhārāja's officers, and not direct to the villagers[1].

CIVIL AID : BRITISH DISTRICTS

As servants of the Supreme Government employed on national duty it was essential that surveyors should maintain close relations both with local district officials and with Political officers representing the central government with Indian States. On the other hand the revenue surveyors were servants of the provincial governments working in close co-operation with district officials, and their work seldom extended beyond certain definite regulation districts.

Topographical surveys were as a rule organized by geographical areas, and not necessarily restricted to local boundaries, though these were an important object of their attention. Trigonometrical surveyors, however, had no professional concern with provincial or political boundaries, but worked from one geographical point to another. They were constantly crossing administrative borders and it was not always easy to maintain close contact with local officers. The following instructions which the Surveyor General sent to Garforth on the Gora series through western Bihār were those normally ruling in every trigonometrical party;

The Collector...attends to these matters, and to him our applications are always addressed. ... I shall address the Government on the subject of your operations, and request that the necessary directions may be given to the local authorities to facilitate your movements. ... I must be furnished by you with...the line of country through which your operations will...pass, and specifying the several Commissioners and Collectors whose aid and protection will be requisite, ... in order that your parties may be duly supplied with provisions, and the arrangements for clearing the rays and compensating the inhabitants may be facilitated[2].

For the Assam series Nicolson asked the Chief Commissioner to warn

the authorities...to assist in the execution of my labours. ... As my advance party will be in Cooch Behar immediately, permit me also to request...your making...to the Rajah...such an announcement...and obtaining for me a confidential man with a few peons from his court to attend my camp during its progress through his country for...rendering aid and furnishing supplies to my party, of the strength detailed. ...

I beg also you will favour me...with a general parwana in triplicate addressed to the landholders, gomastahs, and others of Goalpara District, directing them to supply provisions— ... coolies and conveyances for carriage of property—and labourers for building towers and removing jungle, etc. which may obstruct the visual rays of the principal stations. Every care will be taken that...payment is made on the spot[3].

It was usual for surveyors to rely on local sources for food supplies; there was seldom any attempt to import them. The Surveyor General writes to the Collector whilst inspecting Du Vernet's camp near Jalpāiguri [29, 337–8];

I...found Major Du Vernet's party...depressed in spirits and suffering from sickness. This is entirely attributable to the very inferior food furnished to them by the local authorities, who in some places...afford no assistance whatever. ... The other day...the Rajah's diwan...promised that supplies should be forthcoming, but the provisions having never made their appearance the members of my camp were obliged...to put up with whatever they could obtain.

[1] DDn. 715 (458), Sec. to Ch. Comnr. to Kashmir Svy., 4–1–59. [2] DDn. 495 (44–5), 25–9–44.
[3] DDn. 603 (80), 29–11–52.

The sickness now prevailing is solely attributable to the unwholesomeness of their food, picked up by chance. ... I...hope that you will...exempt Major Du Vernet's party from a repetition of the privations they have undergone owing to the want of co-operation on the part of the local...authorities[1].

District officials further up the valley insisted that the surveyors should make their own purchases at the central markets and refrain from harrassing local villagers. The Assistant Commissioner at Gauhāti writes to Lane;

The impressment of labourers and the compulsory supply of russud [food supplies] is totally illegal, ... and I...would suggest the advisability of your drawing the latter from the markets at Gowalparah and Gowhattee, ... which might easily be managed by keeping up a few boats that could...convey the...supplies to some ghat [landing stage] on the Berhampootra...from whence it might be conveyed by your elephants. ...

With regard to coolies, as it is impossible in many parts of the district to obtain men who are willing to work for hire, the best plan would ...be to keep up a permanent band of labourers for cutting jungle and erecting platforms. ... Your operations should be carried on in the same way as those of all other public departments who, except in the case of troops moving on the line of march, never ask or expect any assistance from the civil authorities[2].

The Collector at Goālpāra was even more emphatic;

I find you have issued a purwana on the mufusil authorities...ordering them to supply coolies and whatever else may be required for your people. ... I have directed the surbarakar ...to pay no attention to your requisition, and I have to request you will for the future refrain from making similar calls on the fiscal officers in this district. ... You must be perfectly well aware that you are wholly unauthorized to assume any such authority[3].

There was constant difficulty throughout Orissa in procuring supplies and labour. Saxton in particular was seriously held up on his triangulation along the coast by lack of labour for jungle clearing [173–4]. The salt department had first claim on the supply of coolies and Saxton was exasperated at the lack of assistance, and appealed to the Commissioner through the Deputy Surveyor General. The Commissioner explained that there was no legal authority by which labour could be compelled to work, even on full payment [III, 410–3];

The Officiating Collector has suggested that...every landholder [be made] liable to punishment for refusing...assistance to every government officer offering due remuneration, but this, ... though theoretically good, is utterly impracticable. Before it could be carried out, the landholders must be vested with powers to impress labourers, and extort supplies when not otherwise forthcoming, and the people must be subject to punishment for...resistance to the orders of the landholders. ... The latter would use the powers...for their own purposes. ...

Much of the trouble experienced by government officers arises from their own neglect of ordinary foresight. If an officer...would arrange beforehand...for the carriage of necessary supplies, and their purchase from time to time, much of the difficulties complained of would cease. ...

There is an incessant cry in Cuttack for aid of labourers and supplies, ... the meaning of which...is either that the sufficient remuneration is not offered, ... or is not paid, to the people, or that they are apprehensive of not being paid. The...Collector...very properly, refuses to interfere...and indeed has no legal authority to do so[4].

Saxton was still left with the feeling that with more goodwill shown by the Collector, and the right stimulus exercised, landholders and *zamindars* might have given greater help to his party[5].

Surveyors suffered much trouble and delay in obtaining official permission to fell trees on their lines of observation, and in getting fair assessment of compensation to be paid [IV, 157–60]. Peyton and Lane had particular trouble in the congested area north of Calcutta [14–5]. Villagers were difficult to satisfy, and local officers often found surveyors high-handed and inconsiderate. One officer asked whether it was really necessary to have caused "every tree in the old graveyard at Cossimbazar to be destroyed, and the monuments to be broken off at the top"[6].

For the Punjab revenue surveyors the Amritsar Commissioner issued a circular order laying down procedure for assessment of compensation;

[1] DDn. 543 (72), to Coll. Rangpore, 27–2–53.
[2] DDn. 706 (359), 15–10–58.
[3] ib. (368), 6–12–58.
[4] DDn. 664 (228), Comnr. Cuttack to DSG., 17–8–58.
[5] DDn. 728 (6), Saxton to Collr. Cuttack, 10–12–58.
[6] DDn. 477 (25), 16–10–47.

There should be three rates of compensation; .... (1), for trees of mature age—(2), for trees of middle age—(3), for young trees. The circumference of the stems of each sort should be carefully estimated, and a common value applied to the sum total of the results of each. ...

The common value will...vary in different localities. ... In respect to usefulness the trees might...follow the order given :—Mango—Jamun—Tallee—Beree—Toot—Phoolee—Kukur—Sirs—Degh. Baneeans and Peepul trees must be valued at higher rates[1].

Fruit trees must receive ten times the average yield of a year, besides the compensation for the wood. Trees growing round wells for the shelter of cattle, etc., should be dealt with as Baneean and Peepul trees[2].

CIVIL AID : INDIAN STATES

Both Lambton and Mackenzie had occasionally suffered obstruction from local officials, or independent *poligars* when working in Mysore or the territories of the Nizām [II, 366–72]. In 1845, Waugh writes to the Resident in Hyderābād, asking for stronger support for Morland's survey, in which

operations have of late been seriously retarded by...hostility and ill-feeling on the part of the inhabitants of the Bassim Circar, and owing to the absence of requisite...co-operation of the local authorities. From my experience in that part of the country, I...believe that the...inhabitants...are a very amiable and obliging race of people, loyally disposed towards their own Government and their British allies, but the followers of the native officials and chiefs are a turbulent set, composed of Arabs...and...adventurers from Hindustan and other parts of the world. ...

It is...always good policy on the part of the surveyor to cultivate amicable relations with the aristocracy of the country in order to avoid the opposition of their servants. ... It is inadvisable to leave the field, because it is only by showing a determination to remain in spite of all opposition that such people begin to find out the futility of offering opposition. I am afraid...that Captain Morland's retirement into cantonments is a...triumph to his opponents, and will render it difficult to re-establish himself with the people of Bassim Circar[3].

When the Surveyor General called for assistance in the Darjeeling Hills, Dr. Campbell, who combined the duties of Superintendent of Darjeeling and Political Agent for Sikkim [83, 473], was at first alarmed by the size of the party, but later agreed to meet all survey requirements within the limits of British territory ;

but in Sikkim I have no powers or authority that can be useful to you. ... I have obtained the sanction of the Government of Bengal to address the Raja on the subject. ...

As regards operations in the Darjeeling territory, I shall be ready at once to meet your wishes in procuring men to clear paths, and in...provisioning the persons so employed and your own people. I can also procure for you the services of a working party of the local sappers. ...

I should like to have 8 or 10 days previous notice...as it takes some time to collect the best description of men, ... to erect shelter for them, and a place to store their food[4].

Du Vernet's assistants had much trouble when working through the numerous small Simla Hill States[5]. After Dyer's trouble of 1849–50 [471], Du Vernet asked the Superintendent to arrange adequate facilities for the following season ;

The...success of the work...will very much depend on the assistance they receive from native authorities in charge of districts and the native princes of hill states. It is...of first importance that these persons should understand the object of the survey—which is entirely topographical—and the necessity of affording every aid in their power...furnishing supplies—proper persons to point out boundaries of districts—and correct lists of villages—...also two chaprasis to attend each camp to procure supplies[6].

He offered to meet the pay of these local *chaprāsis*, recovering it in the party contingent bills ; "without their assistance to carry out your orders, parties would be brought into collision with villagers were they to attempt to procure supplies or...guides"[7]. He was appalled at the prices demanded in the upper Sutlej valley, and appealed to the Surveyor General [203–4] ;

[1] mango, *mangifera indica*—*jaman* or *eugenia jambolana*—*tali* or *shisham*, *dalbergia sissoo*—*bar*, *zizyphus jujuba*—*tut* or mulberry, *morus alba*—*phulai*, —*phulai* or *acacia modesta*—*kikar* or *babul*, *acacia arabica*—*siris*, *albizzia lebbek*—Parker. [2] DDn. 646 (329) 23-2-59. [3] DDn. 453 (246), June 1845. [4] DDn. 463 (413, 419), 7–& 13–4–47. [5] excluding Sirmūr and Bashahr, 27 independent states had total area just over 1,000 sq. miles; cf. *Simla Hill States*. [6] DDn. 608 (22), 4–10–50. [7] ib. (113), 31–1–51.

Unless provisions can be had in my camp at rates suited to the pay of native establishments... work in the direction of the Sutlege must cease. The price of grain about Rampur in Bussawah I expected would be about 20 seers for the rupee, and when I arrived at that place it was selling at 24 seers for the rupee. But...sixteen seers only were allowed for my camp...and only one man was permitted to supply my camp. ...

The whole of my paharees deserted. ... I represented the unreasonableness of taxing my people for the benefit of a buniah, and that if the *waqil* would not order the supply of my camp at the usual bazar rates, the whole of my servants would run away. The result has been that particular orders are issued to supply me at the nirrik fixed for bungalows, and at this place (Sarawan) my camp is served at 14 seers for the rupee, with a deduction of one seer in 12, the seer weighing 77 instead of 84 Company's rupees.

On advance towards Chini I am to be allowed 12 seers, and at Chini 7 seers, beyond which place...flour will be much dearer. ... Neverthless cultivation is abundant. ...

The hill men...have declared their determination to decamp if I would not increase their pay. ... Atta at Dehra sells at thirty seers for the rupee[1].

The necessity of increasing the pay of native establishments whilst in the hills involves additional expenses that will fall unequally on my sub-assistants, those to whom the most difficult work is assigned having also to incur the greatest expense. In regulating the hill allowance [35, 375] it was supposed that hillmen could be hired at four rupees per mensem, but...they refuse to serve though they receive six. ...

I have guaranteed that whenever ata in my camp is less than 16 Company's seers for the rupee, the difference shall be made good to every servant in camp at the rate of $1\frac{1}{4}$ seers per man per diem, which has given general satisfaction[2].

This arrangement was in due course approved by Government.

The Superintendent justified these high prices;

In a thinly populated and ill-cultivated country like Bussahir supplies must ever remain scarce and...dear [III, 41–3], but...it would be highly improper for me to require that the people should dispose of their stores and property at arbitrary rates fixed by me, and other than what they themselves consider fair remuneration, even for the supply of parties employed... in...important public duty. ... The only interference on my part...has been the signing...lists of prices. ... These...were of course not fixed by me, but by the traders themselves. ...

As the party of Captain Du Vernet advances further into the interior, supplies must... become scarcer and dearer, and it is impossible to prevent this. All that I can do is to endeavour to secure for Captain Du Vernet every facility for making his own arrangements with the people...for supplies, and to prevent all interference on the part of the rapacious authorities of the country in enhancing for their own personal advantage the prices of all articles. ...

'I have deputed a confidential man to attend Captain Du Vernet's camp[3].

As a general rule local people were quite ready to assist so long as they were properly paid. *Chaprāsis* wearing official badges were definitely useful but in areas where there was genuine scarcity local officials could give but little help. When Strange complained that he was left "to carry on the work in a most difficult country as best I might" [38–9, 483], the Surveyor General observed that

with rare exceptions, I have never found any disposition on the part of civil authorities to render assistance. ... The best way is to place little reliance on such uncertain aid. Under similar circumstances I used to despatch betimes a trustworthy man of the establishment to recruit the bearers required[4] [III, 410–1, 418].

There were indeed many areas where no local help could be expected, and where it was imperative for the surveyor to equip himself beforehand with everything that he might want. A local police officer told Strange that in parts of Sind where inhabitants consisted only of herdsmen, I found it almost impossible to get hold of a labourer to bring the little water I require for my camp, and it was with the greatest difficulty, that I could get a few men to carry my guns out shooting. I should think that it was utterly impossible to get any of the people of the country to do beggaries work, and that it is just a chance whether there are any people, as there are no permanent villages, and the movements of the different tribes depend entirely on there being a supply of water. ... The people... subsist almost entirely on milk, which is the only article of food procurable there[5].

When permission was obtained for Du Vernet to carry the North-West longitudinal series through the territories of the Māharāja of Jammu, it was carefully

[1] *atta* is coarse wheat flour. [2] DDn. 608 (130), 11-4-51. [3] DDn. 544 (494), Supt. Simla States, to SG., 30-4-51. [4] DDn. 616 (186), 28-6-51. [5] DDn. 629 (4), 21-10-53.

explained that the purpose was "to secure the means of completing the survey of our own territory, and not to obtain a map of *his*". The surveyors were "not to require the names of villages, or any information...respecting places beyond our own frontier [35]"[1]. Du Vernet was told that the Māharāja would depute a trustworthy man as his representative and a sufficient guard. So long as the Maharaja is in Cashmere, or is too far distant from you to allow of ready reference, you had better address your communications to his son, Mian Rumbeer Singh, at Jummoo, sending copies...for the information of the Board. Copies of the...form of address...to both the Maharaja and his son are herewith enclosed. ... You will enforce strict attention to them on your moonshee, as such matters are viewed in a very grave light by native princes [471][2].

The troublesome affair of Trikota Hill was taken more seriously by the British authorities at Lahore than by the Māharāja at Jammu [35–6, 472].

Lane received an unexpected welcome when he visited Patiāla in 1855 to resume work on the Rahun series [50]. He marched in on the morning of 29th October ;

Although so far back as the 29th Septr., I had addressed the Commissioner and Superintendent Cis-Sutlej States, soliciting aid in furtherance of our operations through Pattiala territory, yet up to our arrival at Shekupur, having received no answer, I deemed it advisable... to address His Highness the Maharaja direct, and did so...in the true eastern style. The result was that that same night a waqeel from His Highness was announced in our camp, who next morning accompanied us through the city to our encampment on the other side. ...

His Highness had started off the same morning in company with...the Deputy Commissioner...on a shooting excursion. On our arrival at our encampment...one of His Highnesses infantry regiments was found already drawn up in review order. Presently the corps was put through all its evolutions, and out of courtesy for the attention evinced, I witnessed standing all the varied manoevres, and at the conclusion expressed high gratification on the discipline of the corps and the honour done me. ...

The wakeel who escorted us through the city stated that his brother would attend our camp by order of His Highness, ... and afford all requisite assistance during the course of our operations in the Pattiala territory[3].

Montgomerie started his survey of Kashmir and Jammu early in 1855 with a warning that the success of the survey depended largely on the goodwill of the Māharāja and his servants [221]. The extent of the survey was to depend on the judgement of the political authorities and the opinion of the Maharajah by which you must be guided. It is our object to carry the survey as far as practicable, and... to obtain the means of rectifying our imperfect geographical knowledge of the regions beyond British influence ; but...it will neither answer to risk the safety of the party nor to entangle Government in political complications[4] [237–8].

Some five years earlier the British authorities at Lahore had issued rules for the behaviour of visitors to Kashmir ;

Coolies to be settled with...daily, and to receive 3 Company's annas for every march of ten miles, and half an anna for every 1½ miles above ten.

No interference is to be offered to sardars, thanadars, or other servants or subjects of the Maharaja, and no calls to be made on them except in decided emergencies. ...

If...a traveller or his servants be brought into contact with the Maharaja, his son, nephew, or any of his agents, they must remember they are travelling in the dominions of an independent sovereign, and must treat him and his officers with respect. ...

Where there are bazar or shops, their servants should go to them and not force grain dealers to attend at their tents. Travellers proceeding to Ladak and other places where food is not procurable should take supplies and carriage with them, and should not make demands on the Maharaja's servants. ... Mules are the best carriage ... and make travellers independent of local aid.

Officers proceeding by way of Bhimber[5] will obtain a servant of Maharaja Goolab Singh to accompany them, ... Payment of coolies should not be made through them, but in their presence by travellers themselves[6].

Montgomerie made a point of calling on the Māharāja early every season to keep in personal touch with him. He writes after a three-day wait at Jammu on his way up in April 1856 ;

[1] DDn. 525 (190), FD. to Bd. of Admin., 19–11–49. [2] DDn. 525 (188), Bd. of Admin. to Du V., 26–11–49. [3] DDn. 593 (709), Lane to SG., 15–12–55. [4] DDn. 641 (393); SG. to TOM., confirmed by CD. to B., 9–6–56 (40). [5] to the Pir Panjāl Pass. [6] DDn. 526 (267), 12–4–50.

I saw the Māharāja yesterday afternoon. Everything went off very well, and the result will be well worth the few days that I lost. I was getting rather impatient about it[1].

The Surveyor General was needlessly disturbed by the Māharāja's illness in 1857, thinking that its fatal termination might complicate political relations, and possibly lead to the withdrawal of the survey[2]. But on Gulab Singh's death on 2nd August, he was peacefully succeeded by his son Ranbir Singh, with whom Montgomerie's relations remained just as cordial as with his father. Gulab Singh had been a good friend to the survey and, writes Montgomerie,

even at the very last he was exerting himself...to show that his expressions of goodwill were something more than mere words. ... Personally I have much to thank the late Maharaja for, in the steady and cordial assistance he was kind enough to afford me, ... and I feel sure that I am expressing the general feelings of all the officers and assistants under me when I say that we sympathise with His Highness at the loss he was sustained. ...

I would have sent a persian document but doubted the power of myself or my moonshie to express adequately in a foreign language what I wished to say[3].

During the tragic events that broke out in India nearly three months before the Māharāja's death Kashmir remained entirely peaceful, and Montgomerie's survey proceeded undisturbed [228, 238]; the excellent spirit between the survey party and Māharāja Ranbir Singh and his officers was maintained right up to the close of the survey.

In his report for 1860, Montgomerie describes the conquest of Gilgit for which Ranbir Singh had made elaborate preparations; laying in large supplies of food at the forts of Astor and Bunji during the summer of 1859 ;

Hitherto one of the greatest obstacles to...a successful attack on Gilgit has been the difficulty of getting supplies, "a small force...was sure to be defeated and a large force to be starved". To obviate this a hundred ponies were put at each of the 17 halting places between Kashmir and Boonjee, ... and whilst the weather permitted 100 miles of grain were delivered daily. ...

In June–July of this year [1860] several detachments of sepoys were moved upon Gilgit, mustering finally at Boonjee to about 4,000 men. ... The whole body then advanced upon Gilgit, ... the Maharaja's force losing one man by the bursting of a gun, and the Gilgities leaving one dead man in the fort, supposed to have died a natural death during the siege. ...

This successful expedition has had a very wholesome effect on all the petty tribes lying between Gilgit and the Cabul territories[4].

At a royal darbar held at Srinagar to celebrate the victory there were delegates from Chitrāl, Dir, Swāt, Kolai-Pālas[5], for the first time, besides those from Chilās, Nagar and Hunza "who have been in constant attendance for some years".

Among the minor results of the expedition [writes Montgomerie] was a great influx of presents...from all the chiefs between Gilgit and Kafiristan. Perhaps the most valuable in the eyes of the Curator of the Asiatic Society's museum would have been a splendid live male... markhor. ... This animal was introduced into the full durbar guided by four men with guy ropes. It was really a handsome animal, of a light fawn colour, in good condition, with a capital pair of horns, and a fine long beard. The top of the markhor's head was perhaps five feet from the ground, the horns towering up above all the men in attendance. The keepers...evidently held him in the greatest respect though he had been a captive for at least two months. The markhor was a present from the chiefs of Kholi-Palus on the Indus[6].

The Chilases sent in some very fine half-domesticated goats, a part of which the Maharaja distributed amongst the European visitors to Kashmir. One of these goats now in my possession has a very fine pair of horns of the markhor kind. ...

A great many kyangs [wild ass] have been seen. ... I have watched a herd for a long time at a short distance with a telescope. I have not heard them calling, but Mr. Johnson who caught a foal this year says they bray, and the natives with my camp say the same. I saw a very large skin of a Kyang shot by Mr. Johnson this season in Rupshu. There was a black mark all the way down the back, but not the least sign of any stripe on the shoulders. The ears and tail struck me as being like those of a mule, and I thought them generally very high in the withers, and much larger than any of the wild asses of the Salt Range, ... though bearing a strong resemblance to them [IV, 245][7].

[1] DDn. 51 (12), 15–4–56. [2] DDn. 715 (433), SG. to TGM., 14–4–57. [3] DDn. 716 (152), to Maharaja's Interpreter, Aug. 1857. [4] DDn. 353-A (9–11), 1–7–61 ; cf. Leitner, III (83–6). [5] Kolai-Pālas, about 80 m. below Chilās on Indus R. [6] DDn. 353-A (14–5); 533 (41), 1–7–61. [7] Ib. & 533 (43–4), 1–7–61.

Montgomerie's wide knowledge of the geography of the country contributed effectively to the interception of a body of mutineers who had escaped from Peshāwar in 1857[1], and again in locating the cause and source of the disastrous flood which swept down the Indus in August 1858[2].

MUTINY OF 1857 : GENERAL[3]

The sepoy mutiny of 1857 broke out at Meerut on Sunday 10th May and spread rapidly to all military stations south and east from Delhi. The major military operations which followed were the siege of Delhi which ended with its capture by the British on 14th September, and the siege of Lucknow by the rebel forces where the Residency was relieved on 18th November and the city captured by the British during March 1858. There were scattered outbreaks and general unrest as far as Dacca, Sambalpur, and Nāgpur. In the face of local outbreaks the Punjab was strongly held by the British under the leadership of John Lawrence at Lahore though for many months travel off the beaten tracks was fraught with danger. Wide areas of Oudh and the Upper and Central Provinces were scenes of ravage and bloodshed and military operations throughout 1858.

On the day that news of the first outbreak reached the Surveyor General at Mussoorie, he wrote to offer his services as a combatant officer, but was directed to remain in charge of his department. Though his first reaction was to guard against any local disturbances at Dehra Dūn or Mussoorie, he like many others underestimated the danger. On 22nd May he wrote to his head draughtsman at Dehra ;

> Although no immediate danger is apprehended, yet I...give you discretionary power to fall back upon my headquarters [in Mussoorie]. ... In the event of your being obliged to leave Dehra, ... you will...pack up and bring with you such original and valuable maps and documents as you may deem most worthy of preservation.

On the 25th he wrote to Lawrence Clarke who was marching to Naini Tāl with orders to fix the position of Kāmet Peak [86–7].

> The mutinies...have not spread. Our staunch troops are concentrating on the disturbed districts, and beyond the interruption of the post, and disturbances caused by thieving scoundrels, there seems to be no cause for alarm. My own belief is that the disturbance will be quickly settled. Your party, I think, will be quite safe pursuing its peaceable vocations in the hills. You can...go on with the work as if nothing had happened, unless you are ordered by the civil authorities, ... or any circumstances...render it expedient for you to withdraw[4].

Dehra Dūn was garrisoned by the Sirmoor Rifles, a regiment of Gurkhas, and with Mussoorie remained undisturbed, though under the Surveyor General's direction all survey officers and assistants joined the local defence corps, and with the more stalwart Indian followers were furnished with arms. Amongst the units assembled at headquarters were the Rahun series under Henry Keelan—which had closed field work near Rewāri in April and marched up through Meerut only a few weeks before the fatal 10th May [50]—and the Jogi-Tila party under Tennant who left to join the army before Delhi on 15th August. Both these parties were fully occupied with computations.

The Great Indus series under Walker and Robinson's topographical party were both at Murree where Robinson made himself useful during some minor local disturbances and all the assistants joined the local defence corps[5]. Walker joined the Punjab military column at Rāwalpindi during May and marched with it to Delhi where he was wounded on 14th July and after attacks of dysentery and cholera was granted sick leave to Murree. He resumed charge of the Great Indus series in November. The Kashmir survey continued work undisturbed [481, 485].

Assam was not affected though the triangulation party under Lane had some anxious months at Gauhāti disturbed by rumours of disaffection amongst the troops

[1] DDn. 716 (204), 6-1-58 ; DDn. 51 (35-6) ; 11-& 13-7-57. [2] DDn. 717 (72), TGM. to Punjab Govt., 23-8-59. [3] v. historical account, *Eighteen Fifty Seven* by S. N. Sen, Calcutta, 1857 ; revd., *Ind. Arch.* XI, 1957 (1-2). [4] DDn. 645 (314). [5] DDn. 652 (3); triennial report, 6-10-60 (21).

at Dacca and Chittagong [31, 484]. The topographical parties working in the Orissa States were temporarily switched to minor triangulation along the coast [173–4, *inf.*].

The Calcutta offices under Thuillier were largely employed on maps required for British troops marching up country to join in military operations, and by the forces engaged in the Central Provinces [314–5, 349].

The revenue survey suffered a dreadful catastrophe when the party under Francis Burgess[1] lost all its nine officers and assistants with their wives and families, eleven women and children, all massacred at Jhānsi [267, 364, 396]. Hamilton's party working in Bharatpur in May 1857 was more fortunate and suffered no loss [266], but Blagrave's party was deeply involved at Saugor, and the forest survey detachment at Gorakhpur under Vaughan had to beat a retreat in August [263].

There was naturally very serious interruption to communications, especially between Dehra Dūn and Calcutta, but only one packet of survey instruments was entirely lost. A letter from Mulheran at Ellichpur,

posted on the 6th October, ... reached Dehra on the 5th November...clean and in good order. Parcels, however, may be unable to travel where letters are transmissible. The direct route from Saharanpur to Calcutta has been closed since 6th June, and is now only open for ½-tola letters. ... The country from here to Delhi and Agra has subsided into tranquility[2].

Offices of many civil district headquarters were broken open and sacked, resulting in the loss of maps and other records of the revenue surveys.

James Smith, on transfer from the Jogi-Tila to the Coast series left Dehra on 1st October 1857 and travelling by boat via Multān to Karāchi, and then by sea to Bombay and Calcutta, reached Cuttack in March.

Two elephants left Dehra Dūn on 5th May bound for Cuttack, and reached Meerut on 10th, the day of the outbreak. They were siezed by the rebels but eventually reached the Commissariat at Allahābād and brought on to the books of that department. The *chaprāsi* in charge, by name Ramlagan Singh, fulfilled his trust with remarkable fidelity [374].

Waugh records that at the suggestion of Tennant, "owing to the shortage of hard cash" in Dehra Dūn District, "a paper circulation" was introduced which "answered its purpose very well". Throughout the emergency the salaries of all government servants were paid three months in arrears [376].

On 7th October, within a month after the fall of Delhi, the Dehra Dun offices were able "to resume office business steadily", and Waugh reported that

the field operations have...been attended with a fair measure of success, and in some instances with extraordinary good fortune. Not a single disaster of any consequence has occurred ...and all the valuable records and instruments of the Department are perfectly safe[3].

In this he excluded all reference to revenue surveys. It was some months later that Elliot Brownlow, on 15th March, lost his life by an accidental explosion during military operations at Lucknow. After two seasons with the Kashmir survey he had volunteered for military duty in September 1857 [229, 380].

Probably at the request of higher authority, Waugh submitted a lengthy memorandum on the causes of the Mutiny, the reasons for its measure of success, and the steps he thought should be taken to prevent a recurrence[4].

The most important sequel was the assumption by the British Crown of all responsibility for the Government of India from 1st November 1858 [1][5].

MUTINY OF 1857 : FIELD PARTIES

The two topographical parties in Orissa had spent the recess months of 1857 quietly at Cuttack, but the Commissioner could not approve of their employment in the Tributary States the following season [173], as it would be imprudent to

[1] Francis Burgess ; Fredk. Turnbull ; Daniel Blyth with wife, moth.-in-law & 4 children ; Sgt. Millard, with wife & 3 children ; W. H. Bennett ; J. Young & wife ; G. Young ; Palfreyman ; Munrow ; MT. ; Blunt (155/370–1). [2] DDn. 656 (129) SG. to Mil. Dept. 6–11–57. [3] DDn. 643 (187), to Mil. Dept., 15–10–57 ; v DDn. 643 (209), 25–1–58. [4] DDn. 646 (188–200), undated. [5] DDn. 715 (413), FD., 1–11–58.

carry on any of the usual survey operations this cold season in the Tributary Mehals, or adjoining tracts. ... There is an insurrection at Sumbulpore, and the wild and excitable people of the neighbouring territories are very liable to be influenced by designing men, who...would ...misrepresent your objects. ... Although no disturbances have as yet...arisen in my own immediate jurisdiction, I cannot say...what may not be reported tomorrow, and in the event of any...attack on yourself or party, I have no means whatever of assisting you. ... If you were accompanied by a strong guard the case might be different, but none is available[1].

There was considerable anxiety at Dacca ; and Swiney writes whilst holding temporary charge of the revenue survey party recessing there [254] :

13th June ; we have heard from Sylhet. ... The regiment of Native Infantry located there, although in a state of discontent and insubordination, had not broken out in actual revolt. ...

A private letter from Chittagong received only today has informed the Magistrate that 3 companies of the 12th N.I. (7 companies of which had been disbanded at Barrackpore about a month ago) had mutinied, and that there was a talk of their marching to Dacca. ...

The officers attached to the two companies here speak in the highest terms of the fidelity of their men, but by this slight instance you may judge. ... Of late years the charge of the guns...have been placed with the soobadars. The senior officiating captain...was induced... to take the keys into his own possession. He went over to the soobadar for them, but was very politely refused. The man said that the keys of the powder magazine had been...placed in charge of the soobadars ; ... the officers seem afraid to enforce their orders. ...

The Magistrate has applied...for a company or two of Europeans. ... By turns, the officers in company with some of the...inhabitants patrol the streets all night. ... Guns, pistols, and revolvers are kept loaded and ready...in every house. ... The nuns as well as many of the ladies sleep on board of boats since this panic was started, and many of the ladies with their children have already left for Calcutta. ...

18th June ; Everything is quiet here at present, but we feel ourselves as if sleeping over a mine, not knowing what an hour may bring forth. ... We are anxiously looking out for the arrival of the detachment of marines despatched from Calcutta on the 13th instant. ...

There is every probability of an outbreak if the marines on their arrival go to disarm... the two companies. ... We fear the disaffection that will be created in the regiment at Jalpaigurree, of which the two companies form a detachment. ...

Dacca, although an ancient city, consists for the most part of thatched houses, and the least that the disbanded sepoys can do here will be to burn the city about our ears.

Since writing the above I have just heard that the marines have arrived[2].

There was no outbreak either at Dacca or Jalpāiguri, but three companies at Chittagong mutinied, plundered the treasury, and marched to Sylhet and Cāchār where they were rounded up by the Sylhet Light Infantary, but not before they had spread alarm and despondency to the triangulation party at Gauhāti [31, 482–3].

As work on the Rahun and Jogi-Tila series had to be suspended during season 1857–8, the Jogi-Tila party was employed on the southern end of the Great Indus series, laying out the approximate series [46, 51]. Armstrong marched the party from Dehra Dūn to Ferozepore during November 1857, and was held up there for some weeks awaiting favourable news as to the safety of the river journey down the Sutlej, a British officer having been murdered some weeks earlier. The civil authorities eventually allowed him to proceed under protection of a havildar's guard ;

Considering that my party is proceeding only on a preliminary survey to select stations, ... I have...but a few instruments of inconsiderable value. ... My burden consists of bamboos and ropes principally, which...is expensive in carriage, and it was to avoid this expense and to gain time...that the Surveyor General suggested my progress by boat. ...

Now that the disturbed district has been reduced to tranquility by the energetic measures of the Punjab authorities I would prefer taking the river route to the land one[3].

He writes later to Walker that, with the concurrence of

the authorities and the assistance...of the Commissariat Department I shall leave by boats on the 12th instant, and—D.V.—reach Mithunkote about the 25th with a havildar's guard which the Brigadier commanding has kindly furnished me. I apprehend no molestation on my way, and I shall not fail to use every precaution...to prevent surprise or attack[4].

The journey was completed without incident [48, 415].

[1] DDn. 642 (6), to Saxton, 22–12–57. [2] DLR. 36/30 (177–9), to DSG. [3] DDn. 724 (105), to DC Ferozepore, 4–12–57. [4] DDn. 724 (112), 9–12–57.

Whilst Robinson had some trouble at Murree, chiefly in the procurement of *khalāsis* [213], the Kashmir party was hardly affected. The Surveyor General's letter dated 25th May telling of the outbreak did not reach Srinagar till 11th June [228], and Montgomerie replied at once ;

I have no intention of stopping the work if I can possibly help it. Indeed I should think twice even if the Chief Commissioner were to recommend me to move, at any rate until I had finished Kashmir itself. Shelverton [on the Chenāb] is the only one that seems to have been in the least disturbed by the emeute. The people of Badrawar have got some reports among them, and have made it an excuse for shirking the snow[1].

He found it better, however, to remain himself at Srinagar, where Māharāja Gulāb Singh was dangerously ill, and he deputed Brownlow to take over the principal triangulation across the Deosai Plains [229].

In consequence of the mutiny in the plains [writes Waugh], and the much increased difficulties in getting assistance, cash for drafts, etc., Lieut. Montgomerie found it absolutely necessary to remain near the Maharaja. ... It was only by the most urgent representation and constant personal interviews with the Maharaja that...[he] was able to procure the necessary assistance for Lieut. Brownlow. The Maharaja was willing enough...to order this assistance, but...the petty officials no longer showed their usual alacrity [228, 236]. ...

As the mutiny down country progressed, ... Lieutenant Montgomerie found that his drafts on the Company's treasuries were looked upon as so much waste paper, though the Maharaja was kind enough to advance money on Lieut. Montgomerie's note of hand[2].

On hearing of the fall of Delhi by express message, Māharāja Ranbir Singh ordered a royal salute to be fired at Srinagar on 26th September.

During seasons 1857–8 and 1858–9, Mulheran's party in Berār was greatly interfered with by bands of Rohillas [179 n.1] under Tantia Topi and other leaders, who were moving through the country in search of loot, much in the same way as the *pindāri* marauders of earlier years [III, 82–4]. This unrest was definitely an aftermath of the sepoy mutiny, and the numbers of these freebooters was considerably swelled by the sepoy mutineers. A large force under Sir Hugh Rose spent the whole of 1859 in quelling these disturbances. Tantia Topi had been involved in the events at Cawnpore in 1857, and became one of the most successful rebel leaders, carrying on the struggle against the British forces in Central India till his eventual capture in April 1859. He is described as "the only rebel leader who showed a real genius for war"[3].

In spite of constant alarms, Mulheran's assistants carried on triangulation and planetabling, with frequent interruptions, and turned out a surprising amount of work. The following reports from George McGill show their spirit [179] ;

After finishing my observations at Harkar H.S., I moved...to Manur, and on the same evening I received a letter from Mr. Chamarett intimating that he was...to recall all detached parties owing to the rebels under Tantia having come down. Closing my work, ... I proceeded to Edalabad[4]. On my arrival there the Naib informed me that the country was overrun by "mufsads"[5], and only the day previous had passed through Harkar, making enquiries after me. The whole body moved off to Gima. ...

Acquainting the Naib of my intention to leave Edelabad, he advised me not to do so, as large bodies of armed men were daily passing through Arli, and...my next encampment. Notwithstanding this, I left Edelabad the next day at noon, and on reaching Arli was informed by Ramchunder, native surveyor [447], and the sowars attached to my camp that...a body of 900 armed horsemen...passed through the day previous, making some enquiries after me, and that another large number...were encamped at...a small village 4 coss from Arli.

This body, ... having got information that I was marching to Pussad via Sinkjair, intended moving to the latter, and consequently, giving the men an hour's rest, I moved off for...a village 5 koss from Arli and 3 koss from the left bank of the Penganga. This I did without employing...guides, being well acquainted with the road, and to this...might be safely attributed...our being no more molested. ... The Penganga is unfordable excepting in the place I crossed over, of which all are ignorant excepting the few ferrymen at that spot. ...

To deceive the scoundrels till further...I pretended the next day to take the route via Fealda, but actually took the one through the deserted and jungly portion between Chikal-

[1] DDn. 51 (31) 11–6–57. [2] DDn. 716 (204), SG.'s Report, 1856–7, 6–1–58. [3] *DIB.* (414).
[4] Adilābād, 60 m. sw. of Chānda, CP. [5] *mufsid* = mischievous.

warda and Arni, and on the third day...reached Mr. Chamarett's camp. ... The camp followers were much alarmed. The four sowars were the only trustworthy men I had, and behaved gallantly the whole time I was in jeopardy. I cannot sufficiently express my regret for the loss of time. ... I have...determined upon resuming my work, more so as I was on a similar occasion last year blamed for not showing a bold face[1].

Again, two months later ;

Shortly after my arrival at Bragao I was informed...that there were from 300 to 400 Rohillas in the Kauwat perganah, and that on hearing of my approach they sent a message to the patail intimating that if I had any regard for the lives of myself and party I would not enter the taluka, as they were fully determined to oppose my triangulating any portion. ...

I persisted in entering the taluka by a route south of Bragao. The second night after my arrival in the forest...I and the whole of my party were alarmed by the appearance of a band of men, said to be Rohillas, who approached my tent with lighted matchlocks. ... This body was challenged three times and warned that...I would fire at them. No reply...was received. A quarter of an hour after...they were observed advancing from a different direction, and again challenged. Receiving no reply I fired at them, when they moved off into the forest.

The above...alarmed the whole of my party who refused to accompany me. Fearing, however, that I should be blamed for want of perseverance and energy, I made a second attempt to enter the Kewat taluka by a northerly route. ... After finishing my observations at an isolated hill adjoining the Penganga, the whole of the khalasis, poling jawans, and chobdars, again refused to proceed, basing their refusal upon the certain risk they encountered. ...

After the refusal of my party to accompany me, I employed myself in completing the triangulation immediately south of Mahora Chorad and Patoda hill stations, basing the same upon the Great Arc side Mahora to Bittergaon [III, pl. 18], and connecting with the sides Malt to Patoda and Aragas to Moha of last year[2].

McGill had only joined the survey in 1855 at the age of 17. He became Chief Draughtsman at Calcutta in 1884 [431].

It was owing to this unsettled state of the Central Provinces that the revenue survey parties under Donald Vanrenen and John Blagrave were moved from the Jubbulpore and Saugor districts and employed within reach of Nāgpur [268].

[1] DDn. 654 (98), to Mulheran, 20–12–58. [2] DDn. 654 (142), Ellichpur, 1–3–59.

BIOGRAPHICAL NOTES

ALLGOOD, George. Ben. Inf. & SC.
b. 1-11-27. d. 18-10-1906.
Ens. 20-12-48 ... Bt.-Col. 28-4-68; ret. as Hon. M. Gen. 1-11-69.

Son of Robt. Lancelot Allgood.
ed. Rugby; adm. Aug. 1837.
m., Warden, Northumberland, 24-7-62, Elizabeth, dau. of Rev. Richd. Clayton, of Newcastle-on-Tyne.
CB. 1864; *Who Was Who*; auth., *The China War*.

28-2-56, from QMG.'s Dept., appd. to Kashmir Svy., joining at Srinagar at end of April; survd. by planetable about 1,800 sq. m. on ½-inch scale at east end of Kashmir valley; recalled to mil. duty in Sept. and granted furl. [225, 388, 399, 511].

AQMG. throughout campaigns of 1857-9; China, 1860; Ambela, against Yusufzai, 1863.

ANDERSON, Frederick Cortland. Ben. Inf. & SC.
b. 26-7-27. d. 3-2-1902.
Ens. 13-12-45; BSC., 18-2-61 ... Lt.-Col. 13-12-71 ... USL. 26-7-85; M. Gen. 1-7-86.

Son of Maj. Philip Cortland Anderson (1792/3-1842), Ben. Inf., Hodson, I (33), and wife Lucy, dau. of Harry Younge.
SI. Lists & Services.

1845-6, 1st Sikh War; 1848-9, 2nd Sikh War, with troops on bank of Beās, in ch. siege train; 1851-2, in mil. ops. to N. of Peshāwar making 3-inch svy. of Michni Fort, and whilst holding ch. of S & M. co. building Fort Abazai[1].

10-9-52, asst. rev. survr. Bari *doāb*; Feb. 1856, tr. to Sind-Sāgar *doāb* under Shortrede; in tempy. ch. from 12-11-56; to ch. Bari *doāb* svy. from Nov. 1857, and of Sind-Sāgar svy. *vice* Shortrede from 28-1-58 [7, 213, 274-5, 298, 396, 531].

At end of 1859, party was tr. to Oudh [6, 263-4, 364]; "The Government of the Punjab having no further work, ... the survey establishment during the recess months at Murree finished...mapping and calculations...and, having lodged the whole of the records ...in the local offices, left Murree on 13th October... and proceeded down by bullock train, via Lahore and Delhi, to take up new ground in Oude. ... The Revenue Surveyor went in advance 'by dak' to concert preliminary measures to enter the new district of Pertabghur in Baiswarra Division with the chief portion of his party on 16th December".

Jan. 1860. Anderson was appd. one of two British comnrs. for settmt. new bdy. with Nepāl along N. borders of Kheri and Bahraich, rejoining his party at Naini Tāl at end of May [185, 264][2].

Jan. 1862, inspected by SG., Thuillier, who was on his way "to Capt. Anderson's camp, then at Roy Bareilly, when that officer kindly rode in to meet me at the railway station at Futtehpoor and...met with a severe accident by his horse falling with him and breaking the small bone of his leg, which produced great inflammation, and rendered his moving back to camp quite impossible. ... I was most favourably impressed with all I saw of this energetic surveyor" [397, 400].

Continued to hold ch. of rev. svys. in Oudh and NWP. till ret., 1-11-83, after one year's extension [500].

ANDERSON, George Sligo Alexander [IV, 369].
b. 14-3-22. d. 19-9-85. Bo. Inf. & SC.
Ens. 12-6-38 ... USL. 1-7-81; Lt.-Gen. 7-9-84.

Son of James Anderson of Bridgend, Brechin, co. Forfar, corn merch., and his wife Margaret Clementine Dalgairns; bro.-in-law to James Outram [IV, 420 n.2, 460; V, 374].

3-9-41, appd. asst. supt. rev. svy., Deccan, reverting to mil. duty 1842; May 1845, resumed appt. rev. svy. SMC.; 1848 to ch. Rev. Svy. Ahmadnagar, relieving Davidson [IV, 420; V, 275, 398-9, 494].

1850. Asst. PA. SMC.; 1865. comdg. Nasirābād Bde.

ANDERSON, William Coussmaker [IV, 369].
b. 10-8-22. d. 3-1-93. Bo. Inf. & SC.
Ens. 6-8-39 ... Lt.-Col. 6-8-65 ... USL. 1-7-82; Gen. 1-3-91.

Son of Robt. Anderson, solicitor, of Hereford.
CSI., 1881.

2-3-42, appd. asst. supt. rev. svy., Deccan; 1847, to SMC.; 1848-9, tempy. recalled to mil. duty; 1850, actg. Supt. Svy. & Settmt. SMC.; cnfmd. 1851; from 23-6-52 Svy. & Settmt. Comnr. S. Div.; 1877, Mysore [398].

AUSTEN, Henry Haversham Godwin [489].
HM. 24th Ft. (2nd Warwicks) & Ben. SC.
b. 6-7-34. d. 2-12-1923.
Ens. 26-12-51 ... Capt. 29-10-58; Ben. SC., 26-3-61; ret. as Hon. Lt.-Col. 12-6-77.

eld. son of Robt. Alfred Cloyne Godwin-Austen (1808-84), of Shelford Ho. nr. Guilford; *DNB.*; *RGS. Progs.* XXXVIII, 1885, geolgt., FGS.; FRS.; who added surname Godwin 1853, his wife, Maria Elizabeth, being dau. of Gen. Sir Henry Thos. Godwin, RCB.; *DNB.*; they had family of 16, four of whom lived over 90 y., incl. two over 100[4].

ed. RMC.; "certificate of superior qualifications" [388-9].

m., 1st., Nowshera, 8-4-61, Pauline Georgiana, dau. of Lt.-Col. Arthur Wellington Chichele-Plowden (1814-61), Ben. Inf., Hodson, III (538-9) and sis. to wife of A. B. Melville [512], at whose wedding at Debra, 27-3-65, Pauline Austen (*sic*) sd. as witness. A week-old son d., Mussoorie, 16-6-62, and a son, Robt. Arthur, was b., Srinagar, 14-9-63. Pauline d. in 1871; a nephew, Robt. Annesley, b. 1885, CBE, had long survey career mostly under Colonial Office.

m., 2nd., England, 1-6-81, Jessie, dau. of J. H. Robinson, clerk in House of Lords; she d. 21-7-1913.

DNB.; *Suppl. 1922-30*; *DIB.*; *Ency Brit.*; Markham (172-3, 429-30); Markham's *Abstract*, 1876-7 (14-5); *GJ.* LXIII, 1924 (175-6), ob. by Holdich; Mason, with portrait (76-8); another portrait [pl. 23].

FRGS. 1859, Founder's medal 1910, *ASE Progs.*, 1869, *Geology Jaintia Hills*; *Great Cachar Earthquake of 10-1-69. RGS. Trans.*, IV, 1859-60 (29-31), sketches of Himālayan scenery; *RGS. Trans.*, V, 1861; VIII, 1864; XI, 1867, XVII, 1873, papers on Kashmir[5], Mustagh Range, Pangong Lake[6], Garo Hills [240]; *JASB.* 37, 1868 (83); 38, 1869 (2); 44, 1875 (37); Geology.

Auth. of *Land & Freshwater Mollusca of India*, pub. 1882-7; Papers on Indian survey, 1884, 1894, *RGS. Progs.* V 1883 (612-20); as Presdt. Geogl. Sec., Brit. Assn., read paper 26-9-83, on *Ranges of Himalaya*. *J. Anthropological Inst.* May 1871 (122), *Stone Monuments of the Khasi Hill Tribes.*

1852-3, arrd. India; Burma War; ADC. to Gen. Godwin, 1856-7, ADC. to Gen. Reid at Peshāwar; passed in Hindustani; drew sketch map from svys. by Peter Lumsden and Garnett [217], *IO Cat.* (467).

1st batt. HM. 24th Ft. arrd. Calcutta 1846; 1857, at Ferozepore, with 2 cos. at Pindi.

Under BMC. 5-4-57, joined Kashmir Svy. at Srinagar, 3-5-57, as tempy. topo. asst., and after instruction by Montgomerie made "very artistic" planetable sketch of Jhelum valley below Bāramūlā [227, 229]. After cold weather at Dehra Dūn worked in Jammu foot-hills from Feb. 1858, services having

[1] 31 m. N. of Peshāwar. [2] DDn. 668 (203), FD. to DSG., 17-9-59. [3] *GR. Rev.*, 1858-61 (98). [4] *Times*, 5-1-1943, "Longevity in 1942". [5] read 12-12-59, *JRGS.*, 31, 1861 (30-7) [6] GBO. Lib. Ba5, & *GR Trig.*, *1863-4*.

KASHMIR SURVEY





THOMAS GEORGE MONTGOMERIE
(1830-1878) F.R.S.
Bengal Engineers
G.T.S. 1852-73
In charge Kashmir Survey, 1855-65
Offg. Supt. Trigl. Survey, 1870-72

HENRY HAVERSHAM GODWIN-AUSTEN
(1834-1923) F.R.G.S.
H.M.'s 24th Foot & Bengal Staff Corps
Topographical Assistant, Kashmir Survey, 1857-63
In charge topographical surveys, including
Khāsi & Jaintia Hills, 1864-77

JAMES THOMAS WALKER
(1826-96) F.R.S.
Bombay Engineers
S.T.S. 1861-84
Surveyor General 1878-84



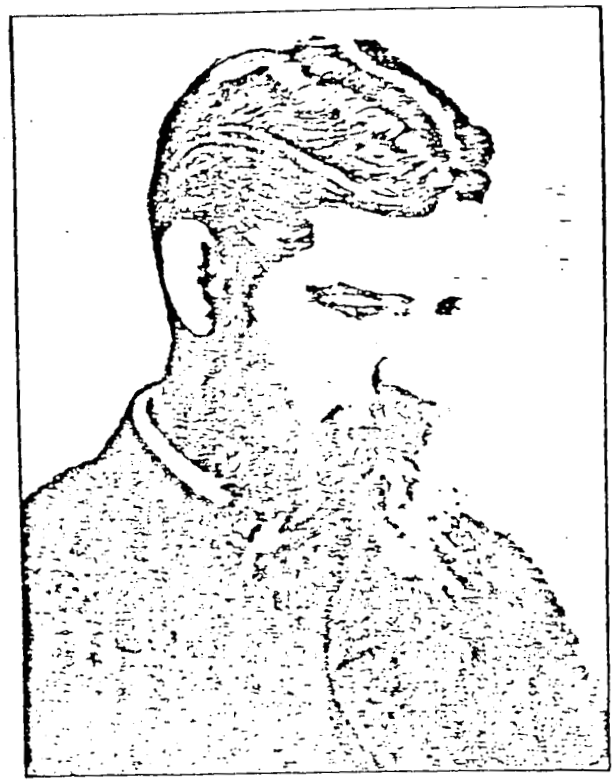


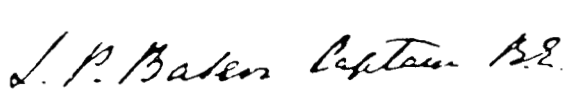
ALEXANDER STRANGE
(1818-76) F.R.S.
Madras Cavalry
G.T.S. 1847-60



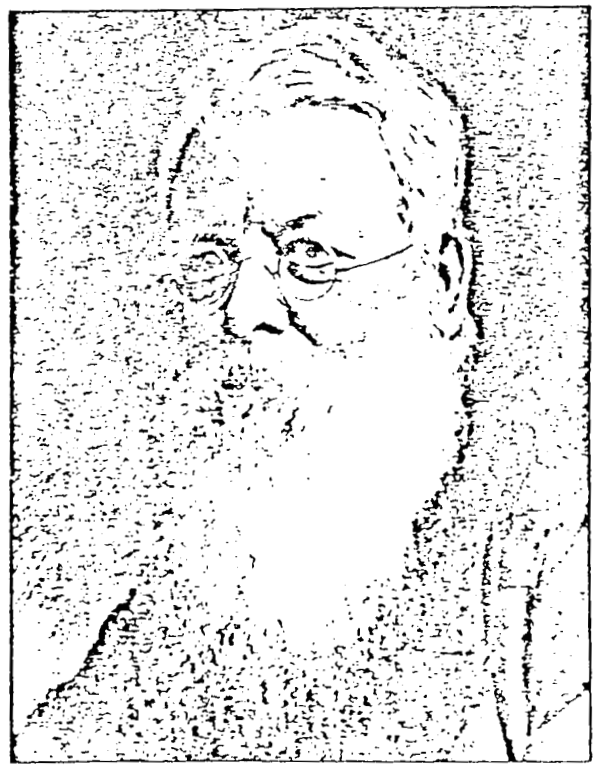


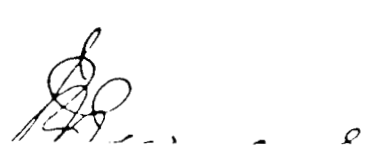
(1831-71) F.R.S.
Bengal Engineers
Died making pendulum observations
in High Himālaya





JAMES FRANCIS TENNANT
(1829-1915) F.R.A.S.
Bengal Engineers
G.T.S. 1850-59





been "permanently" placed at SG.'s disposal from 22–2–58, with allce. Rs. 250 pm., and seniority above Melville and Murray [388–9, 399][1].

Continued svy. to E. of Jammu throughout 1858, though laid up for several weeks after brutal attack by villagers in Nov. [230–1, 475–6].

Promoted Capt. in 2nd Batt. on home service and, after sending in finished sections from Sialkot, 7–3–59, left for Bombay [232]. SG. asked for his re-appt. to svy. should he ever return to India. "He...has exhibited a high order of talent as a field draftsman in delineating difficult ground. The mountainous...character of the tract in which he has been employed is such as to tax severely the physical strength...of all engaged on the survey" [389][2].

Early in 1860, obtained retransfer by exchange to 1st Batt. in India. He left 2nd Batt. at Cork and from Bombay wired SG., 25–4–60, asking for reposting to svy.; sailed following day for Karāchi to join 1st Batt. via Multān where he recd. orders to rejoin Kashmir svy. Reported to Montgomerie at Srinagar 1st June after break in deptl. service of 1 y. 14 d., later condoned[3].

As 1st Batt. was due to leave India during 1861, SG. obtained sanction for Austen to remain in India pending appt. to newly formed Staff Corps, and his career in svy. dept. was now assured[4]. There were the usual delays in issue of allces., and he writes from Dehra Dūn where he had just become engaged to be married, pressing "for some advances of military pay. ... With the heavy travelling expenses in the field...I am now very much pressed...by different tradesmen with whom debts have...been contracted since the sudden reduction in my allowances has...prevented my own servants receiving their pay. ... I...do not wish to involve myself...by borrowing money at ruinous interest"[5].

He was still pressing for adjustment of allces. some two years later and was probably, writes Montgomerie, "the only officer in India who has actually lost pay by joining the Staff Corps". He was not promoted to the higher sc. scale, Rs. 450 p.m., until late in 1863, after being twice recdd[6]. Promotion to the full svy. allce., Rs. 618 pm., for ch. of svy. party was held up by diversion to Bhutān mission [*inf.* 390].

1860–3 had four seasons in highlands of Baltistān and Ladākh, sketching on ¼-inch scale with happy flair for catching mountain forms. Spent 1860 and 1861 on the Indus and Karakoram, from Skardo and K2 westward and sketching distant peaks of the Mustagh [89–90, 235][7]. 1862, survd. Zānskar Range south of Indus from Drās to Morari Tso, and in 1863 worked N. and E. from Leh and up the Changchenmo to Pangong Lake and limits of the Māharājah's territories [237, 239].

At Pal on N. bank of lake had friendly meeting 4–6th Aug., with Govr. of Rudok, who regretted his inability to invite GA. there. On his return GA. halted at Kyam hot springs, 15th Aug. [490 n.9]; *JRGS.*, 37, 1866–7 (356).

On Ladākh road, about 2 m. w. of Drās, is a large boulder bearing the initials HHGA, 1861–62–63[8].

By temperament and physique Godwin Austen was the ideal man for topo. svy. under roughest conditions [389]; but it was his work on the high Karakoram that attracted particular attention and led to the unfortunate suggestion that his name should be given to the peak that Montgomerie had discovered and had designated K 2, and for which no local name has been found [5, 88–90][9].

Sept. 1863, completed work in Ladākh and left for Mussoorie *en route* to take ch. of topo. svy. of Khāsi Hills, as sanctioned from 1–10–63[10]. Received instns. at Lahore direct from FD. —without ref. to SG.—"to accompany the Mission to Bhutan as Surveyor and Assistant to the Political Agent "[11].

Accd. SG. from Dehra Dūn to Calcutta, and joined Ashley Eden at Darjeeling in Nov. Leaving Darjeeling 4–1–64, Eden reached Punaka on 15th March. Austen worked svy. across with utmost difficulty—the mountains were covered with dense forest—winter conditions brought heavy snow with blinding storms and breast-high drifts—inhabitants were generally unfriendly—several of his men got frost-bitten, and two succumbed in the snow[12].

Oct. 1864 to April 1865, served with Bhutān fd. force in Duārs campaign, leaving Calcutta 27–10–64 to reach Gauhāti 19th Nov.; joined right col. in capture of Dalimkot and Chumurchi, and made ¼-inch sketch of W. Duārs and S. slopes of Bhutān hills from Tista R. to Buxa[13].

Now thoroughly ill after two strenuous seasons in unhealthy country, spent rains in Mussoorie, writing to SG. from Dehra, 15–5–65, "at present by no means strong; I propose resting here a short time". After 6 mo. leave to England rejoined at Dehra 27–3–66, and took ch. of FZO., work including printing of Map of Central Asia[14].

From Oct. 1866, held ch. of No. 6 Party, K. & J. Hills now drawing the full svy. allce., and posted to Topo. Br.; took two y. furl. April 1870 to Oct. 1872, and again Aug. 1873 to Oct. '74, with two spells mil. service, Nāga Hills, 1873, and Daphla Hills, 1874–5. Leave pending rett. 11–8–75[15].

After rett. worked on "land and fresh-water mollusca", pubg. a series of papers, 1882–99. Mason found him in his 90th year still enjoying dissecting snails and other unpleasant creatures, examining them under the microscope, and preparing exquisite coloured sections of their internal organs.

Keenly interested in zoology and ornithology, worked for Indian Museum at Calcutta for some months during 1877[16].

Mason visited him at Guildford a few months before his death and found him "a very forceful old man", insistent that all the new-fangled gear such as clamps, ice-axes, ropes, etc., should never be used by any self-respecting mountaineer.

In all official correspondence and documents before 1863[17] referred to as Lieut. or Capt. Austen, and only rarely is the name Godwin included, and then without the hyphen. The autograph [pl. 23], sd. before 1861, shows no hyphen and in 1865 his wife signs without the Godwin [489].

[1] DDn. 642 (21, 113), MI. Dept., 22–2–& 5–9–58. [2] DDn. 643 (273), SG. to AG. HM. Forces in India, 25–1–59; DDn. 51 (52), Austen to SG. 7–3–59. [3] DDn. 52 (72), SG. to Austen, 15–5–60; 93 (247), SG. to Mil. Dept., 11–4–66. [4] DDn. 21 (8), SG. to Mil. Dept., 23–1–61; reply, DDn. 1 (35), 23–2–61. [5] DDn. 51 (69), to offg. STS., 17–1–61. [6] DDn. 51 (89), TOM. to STS., 12–9–62. [7] photostat of PT. section Karakoram area, Svy. Museum; corr. *Times*, 11–12–1959. [8] Photo., Svy. Museum. [9] *GJ.* LXIII, 1924 (175–6), Holdich wrongly accredits discovery to GA.. [10] GO., 18–9–63; DDn. 52 (268). [11] GO., Mil. 702, 30–10–63. [12] Eden (61–78); Sarkar (86–95); Reports, DDn. 73 (SGO. 135), 1863–5, Pol. Progs., A., Sept. 1864 (45–7); ¼-inch map, MRIO. 90 (5, 6); *GR. Topo., 1864* (appx. A, XXV). [13] Maps, *IO Cat.* (471). [14] SG. Corr., May 1865 (34); Oct. 1865 (57–8). [15] Markham (172–3); *IO Cat.* (303); *GR Topo. 1872–3* (97), Narr. of Naga Hills Svy. with sketch of ruined fort, sd. G A., Shillong 14–6–73. [16] *Statesman*, 12–2–77, quoted 12–2–1952, in "*75 years Ago To-day*". [17] except *Ben. AL* 1858 (93).

BAGGE, Arthur Herbert. Ben. Engrs.
b. 12-2-38. d., London, 19-1-71.

2/Lt. 12-10-56 ... 2/Capt., 10-11-69.

Son of Henry Case Bagge, BCS., and Margaret his wife, dau. of M. Gen. Herbert Bowen (1760-1851), Ben. Inf., Hodson, I (185-6).

1861, with FWD. on Ganges Canal.

BGO., 5-12-62, appd. Pegu Svy., joining 7-3-63; with Fitzroy on trgn. across Arakan Yoma [198, 399].

Withdrawn from Pegu Svy., 17-12-64, and posted to bdy. comn. Tenasserim-Siam border as survr.; *IO Cat.* (308), Maps of Tenasserim.

BAIGREE, Robert. Bo. Inf. & SC.
b. 28-1-29. d., Poona, 25-9-77; MI.

Ens. 3-2-48 ... Col. 20-11-74.

Son of John Baigree, of Fearn, co. Ross.

CB., 24-5-73. Portrait, *ILN.*, lxxi, 1877 (481-2).

As DAQMG. made plans and sketches of Mālwa *forts*, MBIO. Misc., 57/66-0-60, and others in Rājputāna, MBIO. 84 (29, 42), 187 (35), all most artistic [191].

Well-known as amateur actor, *JUSI.* LXXVIII, 1947, 327 282), *British Officers' Versatility.*

QMG. Bo. Army to 1874; OC. 28th Bo. NI., 1876 to death.

BASEVI, James Palladio. Ben. Engrs.
b. 23-3-32. d., Changchenmo, E. Ladākh, 17-7-71; MI., Srinagar.

2/Lt. 12-12-51 ... Capt. 31-10-68.

Son of Geo. Basevi (1794-1845), FRIBA.; FSA.; FRS.; architect, *DNB.*, and his wife, Agneta Frances (Agnes), dau. of Joseph Seymour Biscoe, of Hampstead Court, Glos., *formerly* of Frankfort, Germany. Architect of Fitzwilliam Museum, Camb., and kd. by fall from tower of Ely Cathl. Was of Jewish *family from* Venice which adopted Christianity after immigration to England; 2nd. cous. to Benjamin Disraeli, later Lord Beaconsfield[1].

James' eld. bro. Geo. Henry (1830-82), of Prestbury, Glos., became Col. in Ben. Army, and dsp.; a nephew, Henry Basevi, was comdg. an Indian batt. at Nasirābād in 1912, and d., 1936, at Bordighera, Italy.

James Palladio—2nd name derived from an eminent Italian architect, Andrew Palladio (1518-60), *Ency Brit.*— was ed. Rugby from Feb. 1843; Cheltenham, Jan.-Dec. 1849, Addiscombe, 1850-1, taking Pollock Medal, Sword of Honour, and other prizes, incl. that for mil. svy.

m., Wraxall, nr Bristol, 21-7-64, Charlotte Louise, dau. of Henry Wooley of Bath; she d. at Bath, Dec. 1919, aged 77. Their eld. son, Wm. Henry, b. Mussoorie 1865, joined Army Pay Dept., m. Miss Ethel Gill, and d. as Col. 1945. Their 2nd son, Chas. Lionel, b. 1867, ed. RMA.; Lieut. RA., 1886; resd. 1889, was ordained RC. Priest and d. c., 1948.

James, son of Wm. Henry, served with Canadians 1914-8, winning DSO. and rising to Major; m. Miss Gwendolen Weatherall; became Art Director of Films, Hollywood 1947.

Notices:—*RAS.* (MN) XXXII (110); *JRGS.*, 43 (CLX) *RGS. Progs.*, XVI, 1871-2, (306-10); Conolly (92/282); Markham (141, 160); Markham's *Abstract*, 1870-1 (22); Vibart (577-8); Thackeray (225); *GTS.*, V (X-XI); *GR Trig., 1870-1* (18-21 & appx. 62-6); *Times*, corr. from JTW., 19-9-71; *Blackwood*, serial 1578, April 1947 (341-7)[2]; Sandes, II (202-13).

FRAS. 1864; portrait pl. 22.

Arrd. India 1853, emp. Punjab Canals.

17-1-56, appd. 2nd. Asst. GTS., joining at Dehra April [519]; posted to Jogi-Tila party under Walker, joining at Jhelum 9-4-56, and emp. 1856-7, on obsn. final polygon of NW. longl. ser. nr. Attock [47].

May 1857 tr. to Kashmir svy. and emp. on svy. and mil. report on passes over Pir Panjāl between Gulmarg and Banihāl; on svy. Jhelum R., Islāmābād to Bāramula, and its possibilities for nvgn., and of Manasbāl and Wular lakes [48, 227-8, 287].

At end of 1857 rejoined Gt. Indus ser. and next three seasons carried prepl. triangles S. ward to Mithankot, with recess months in Murree. SG. acknowledged his work as placing him "in the first rank as an observer" [48-9, 79, 133, 151, 340, 380, 382].

March 1860, made rapid recce. into tribal hills; "my expedition was fruitless, the atmosphere being so thick on Gandhari that I could see nothing. I returned marching with laden camels through the hills by an hitherto...unexplored route...into the Chackur Durra, and issuing from the hills opposite Drigree arrived at Dajal on the 1st of April[3]".

April and May, 1860, with Walker and Branfill into Mahsūd country on mil. expn. led by Brig. Gen. Neville Chamberlain; carried out valuable svy. under active service conditions [49, 217, 508, 540][4].

Oct. 1860 tr. to ch. of Coast Series which he took over from Clarkson at Vizagapatam on 1st Dec. after arduous journey across the continent [29, 415]. After extending triangles S. ward for two seasons he returned at end of 1862 to select site and assist in meast of base-line at Vizagapatam [29]. Then during Feb. to April made recce. svy. into the little-known territory of Jeypore[5], long avoided by surrvrs. on account of deadly climate [III, 193].

With detachment of only 12 men, reached Jeypore on 8th March 1863 after journey of 27 days, his asst. James O'Neill having been sent back with fever. After two weeks at Jeypore Basevi marched another 150 m. SW. to the Godāvari and up that river to Bhadrachalam. River was too low for return journey by boat so he marched over the hills to Ellore, and then by Rājahmundry to reach Waltair 23rd April; the full round trip more than 600 m [pls. 1, 28][6].

Aug. 1863 to Dec. 1864, on furl. to England where he married and made his first contact with problems of gravity research. For next 7 years emp. on pendulum obsns. in India, obsg. at some 19 stations along Gt. Arc—2 on E. Coast—2 on W. Coast, and also at Minicoi in Laccadive Is.[7]. Season 1868-9, took ch. of base meast. at Cape Comorin.

In 1871, to extend this wide series of gravity obsns., took pendulums into high Himālaya. With asst. James(?) McDougall, who had been with him since 1866, left Dehra 27th March and travelled up through Kashmir to Ladākh to swing pendulums on Moré plain some 80 m. SE. from Leh towards Rupshu, over 15,000 ft. above sea[8]. He then moved N. of Indus R. and up Changchenmo valley to point near W. end of Pangong Lake, nearly 100 miles east of Leh, more than 17,000 ft. above sea-level, wholly in the uninhabited "Lanak maidan"[9], 2 marches to E. of Kiyam". Here he died [399].

[1] c. *Disraeli*, D. L. Murray, 1927 (18). [2] *Basevi of the Pendulums* by Lt.-Col. P. R. Butler, whose help is here warmly acknowledged. [3] DDn. 692 (511), to JTW., 6-6-60; Dājal c. 40 m. S. of Dera Ghāzi Khān [pls. 1, 28]. [4] Paget & Mason (526) [5] c. 150 m. NW. of Vizagapatam. [6] *GR. Trig., 1862-3* (appx.), & DDn. 697 (144-61), report dated 26-6-63; ½-inch map, MBIO. 135 (9) & GHO. Lib., D—3; 8-in redcn., *IO Cat.* (201). [7] *JASB.* XXXIV, 1865 (251-72); *Roorkee Papers*, II (97-198, 199-203), serials, 135, 137, 148. [8] modern value, lat. 33° 16′ N., long. 77° 21′ 30″ E.; results from Basevi's obsns., *GTS.* V (213-4). [9] modern value lat. 34° 10′ N. long. 79° 22′ 30″ E.; Lanak La 18,000 ft. on modern Map; Kiam on map 16, *NF Atlas.*

Owing to scarcity of provisions and fuel, he had left McDougall at Tangtse to compute the Moré obsns. On 10th July, crossing Mesimik Pass, 18,629 ft., had a 7-m. tramp through a storm of rain, hail, and sleet, and obviously caught severe chill. Friends from Dehra Dūn who had met him earlier that day[1] found him in excellent health—"never looking better or in higher spirits"—but on 14th, after three more marches, his bearer noted that he was suffering considerably and the next day, after reaching last camp and setting up theodolite, he developed a severe cough, with pain in his chest, and had to lie up. He was in trouble all next day, keeping to bed, and died early on 17th, obviously of pneumonia[2].

How many surveyors have given their lives to their work in like manner, alone in the jungle, or by the roadside, or on the mountains [417, 428, 518].

His faithful bearer, Paraoti by name, at once started the march back, meeting McDougall on the way. The body was buried temporarily at Tanktse, and was later moved to Srinagar and buried in the christian cemetery there. Besides the bronze plate over his grave there is also, writes Frank Ludlow in 1948, a stone slab 12″ by 4″ in the Residency cemetery at Leh, crudely inscribed to Basevi. This had been brought in about 1932 from a "mani wall" at Shyok village a few m. N. of Tanktse.

Walker pays a warm tribute to Basevi's pioneer work on the Indian pendulum obsns., *RAS.* (*mn*), xxxii (100–11), 9–2–72. He notes that the "pendulum" chapters I to V of *GTS.* V "passed through press as nearly as possible in his own words". Hennessey notes that Basevi "alone in India was thoroughly conversant with the pendulum operations"[3].

"Captain Basevi" writes Montgomerie, "was an officer of rare scientific and general attainments. ... He had done good service in every part of India, from Ladak to the southernmost point of the Madras Presidency, one of his special charges having been the measurement of the Cape Comorin Base-line, ... but the crowning work of his life was the taking of the pendulum observations for the whole continent of India. To this most difficult task he devoted a large amount of talent and labor, of which it is hardly possible to convey an adequate idea [380, 399]. ....

"His labour will supply exceedingly valuable data towards solving the most interesting and difficult scientific questions as to the ellipticity of the earth and...variations in the density of its crust[4]".

Basevi records that between 1867 and 1869, his wife often recorded his obsns. in the absence of his asst. McDougall[5]. She was in England at the time of his death, and was granted pension of £100 a year from the Home Civil List, by influence of the Prime Minister, Benjamin Disraeli[6].

A subscription of over Rs. 2,000 for a suitable memorial was raised in the Department. After consulting his widow, a clock was purchased in England and installed in 1874 over the office porch at Dehra Dūn. "It strikes the quarters as well as the hours and keeps admirable time, and has altogether superseded the hand-struck gong by which for very many years the office hours have been regulated". The inscription was added in 1904[7].

BATTYE, George Money. Ben. Inf.
b. 19–3–29. d. 13–10–1912.

Ens. 20–8–45 ... Bt.-Col. 20–8–76 ; ret. as M. Gen. 20–11–77.

Eld. of ten sons of Geo. Wynyard Battye, BCS., of Holmfirth in West Riding, Yorks., and Marian Martha, dau. of James Money, his first wife ; bro to Henry Doveton [*inf*].

m., Hampstead, 15–12–59, Emma, dau. of E. C. Smith, BCS.

GO. 2552 of 13–11–50, appd. to trans-Sutlej rev. svy., having joined from 1st Eur. on 1st Nov. [273].

Sept. 1852 to Oct. '54, with his regt. to Burma on mil. service, Thos. Blagrave then writing that as he had "been so long absent, he will be the better of a few months brushing up at both field and office work ere obtaining the management of a survey. ... The survey department is not like a corps of irregular cavalry from which a man may be absent for years without detriment, either to his own interest or those of Government" ; to which the DSG. added marginal note in pencil, "I should think NOT"[8] [400].

DSG. later notes that Battye, "not having much taste for the profession, ... obtained another appointment in the Punjab as Assistant Commissioner", under GO. 4678 of 15–11–54[9]. In 1860 he was Asst. Comnr., Ferozepore, and in 1864 PMG. of NWP., when STS. addressed him regarding svy. mails addressed to the Gwalior & CL party ; 'of four packets that reached me yesterday (on tour), one had been from Agra to Jaipore, to Kerowlee, to Gwalior, to Shapore, to Shahabād, and at last reached me near Jhara Ghat'[10].

Ret. as PMG. Bombay.

BATTYE, Henry Doveton. Ben. Inf.
b. 5–10–33. d. 20–2–15.

Ens. 7–1–50 ... Bt.-Col. 7–1–81 ; ret. as M. Gen. 25–8–84.

bro. of Geo. [*sup*].

m., 16–1–62, Susan, who d., 17–8–63, dau. of Dr. J. J. Boswell.

Who was Who.

10–9–52, appd. to rev. svy. Rechna *doāb* under Thos. Blagrave who reported in 1854 that, "now that he has had another year's acquaintance of the work, I can honestly report that, though a little wanting in energy, he is the hardest working and most careful assistant I have" [this is underlined, and queried in pencil by DSG.]. "He is perfectly master of the office work, and though not yet a good draftsman or printer, he is very much improved"[11].

He later joined his batt. for ops. against Santāls [372, 499], and did not return to svy. [400].

8–12–55 Asst. Comnr. Jhelum[12] ; 2nd.-in-comd. 1st Sikh Inf., 9–2–58.

BECHER, John Reid [IV, 419]. Ben. Engrs.
b. 3–7–19. d. 9–7–84.

2/Lt. 11–12–37 ... Maj. 2–8–54 ... Col. 15–9–81 ; ret. 1866 ; Gen. 29–11–78 ; Col Comdt., 15–9–81.

8th son of Col. Geo. Becher (1780–1837), Ben. Cav., *Hodson, I* (116), *DIB.*, and Harriot Gildard, his 2nd. wife. CB. 1860 ; *DIB.* ; Conolly (89/197).

[1] Maj. Macintyre of 2nd Goorkhas & Maj. Macdonald, on shooting expn. [2] details from bearer recorded by Hennessey, *GR Trig., 1870–1* (appx. B, paras 12–17). [3] *GR Trig., 1856–8* (appx. lvii) ; *1858–9* (appx. xxviii) : cf. [4] STS. to GI. (Agri. Dept.), 17–8–71 ; reply No. 175 of 1–9–71. [5] *GR Trig., 1866–8* (appx. lvii) ; *1868–9* (appx. xxviii). [6] JTW. to W. H. Cole, 17–5–83. [7] *GR Trig., 1873–4* ; frpce. to *GTS.* V, shews porch without clock. [8] DDn. 483, 3–10–54. [9] DDn. 624 (74), DSG. to SG., 5–4–56. [10] DDn. 9 (120), 27–2–64. [11] DDn. 483, 30–10–54. [12] DDn 426 (74), DSG. to SG., 5–4–56.

ed. Bruce Castle, Tunbridge Wells, and Addiscombe.
arrd. India, 1839; 1843, with Pollock's column to Kābul; 1st Sikh War, wounded at Sobraon, 10-2-46.

19-10-46, to ch. rev. svy. trans-Sutlej *doāb*, at Phillaur; Oct. 1847, tr. to Lahore Agency, and 1848 appd. Asst. to Resdt., as Comnr. on Bikaner bdy. [191, 270, 364, 400, 504].

1853-9, DC. Hazāra; 1859, consulted Montgomerie re Indus floods [515].

1862, as DC. Derajāt appreciates valuable help of Johnstone's trans-Indus *pargana* maps, whereas main-circuit plans of cis-Indus areas were of little admin. value [218-9, 297-8]. He adds; "With all its barrenness this would not be a bad country were one nearer to friends and civilization. As it is, it is a kind of exile. ... For myself, I do not often turn back with longing for home, except when I am weary of work. I dread the monotony of life in England[1].

BLAGRAVE, John William Barwell. Ben. Inf.
b., 1824; bapt., Calcutta, 25-3-24.
d., Saugor, 6-10-57; MI. St. James' Ch., Delhi.

Ens. 24-4-41 ... Capt. 11-11-54.

in 7th generation from eld. bro. of John Blagrave (d. 1611), mathn., *DNB.*; son of Chas. Geo. Blagrave, BCS., from Calcot Park, Berks, and his wife Jane Colvin; bro. to Thos. [*inf*].

Punjab Inscr. (28).

arrd. India Aug. 1841; 15-11-47 appd. asst. rev. survt. trans-Sutlej *doāb*; after tr. to cis-Sutlej, returned to ch. on Hutchinson's death in 1848 [505] till his bro. took over [6-7, 270 n.7].

Oct, 1850, raised new party for Bari *doāb*; 1853, sick leave and furl., sailing 7th Feb. [272-3, 499].

Jan. 1854, on return from furl. joined 74th NI. at Cawnpore, and in Aug. raised new party for rev. svy. Saugor. "An officer of great energy and good professional knowledge, and has always given much satisfaction"[2] [268, 364-5, 400, 543].

d. Saugor Ft. during siege by mutineers [397, 483].

BLAGRAVE, Thomas Colvin. Ben Inf.
b. 25-3-18. d. 21-10-97.

Ens. 3-1-36 ... Maj. 11-8-58; ret. as Lt.-Col. 31-12-61.

eld. bro. to John [*sup*]; m., before 1862, Jeannette Louise, who d. Bognor, Sussex, 5-1-98, aged 55.

1844-5, asst. on Sind svy.; *JASB.* XIV (cviii), 1845, reports, 16-10-45, Karāchi earthquake and founding of local science instn; XV, 1846 (xvii), elected member ASB.; 1st Sikh War, at battle of Sobraon, 10-2-46.

10-2-47, appd. asst. rev. survt. trans-Sutlej; Oct., tr. to cis-Sutlej till 4-1-49 when returned for ch. under GO. 27-12-48 [7, 201, 270-2, 316, 350, 396, 433]. Moved 30-8-52 with party to s. Rechna *doāb*, Lahore and Jhang dists. [7, 273-4, 365, 491, 500].

Under GO. 1-2-56, made over ch., 9-1-56, to John Macdonald, after declining tr. to Sind [277]; from 1-8-57, comdg. 12th Punjab Irreg. Inf. [400].

BLAIR, Gustavus Frederic. Mad. Art.
b. 3-1-33. d. 1-10-1902.

2/Lt. 14-6-50 ... Lt.-Col. 1-8-72; ret. as Bt.-Col. 8-10-73.

Son of Lt.-Col. Chas. Devaynes Blair 1804-60, CB., 8th Ben. Cav., Hodson, I (158-9), and his 1st wife, Martha Cordelia, née Crichton, who d. Nasirābād, 23-10-40.

1-8-56, appd. to Pegu Svy. under Edgecome, reverting to regtl. duty 20-8-57; rejoined for season 1858-9 [197].

BODDAM, Castle Tudor. Bo. Engrs.
b., Agra, 1825/6.
d., Jubbulpore, 2-5-61, aged 35; MI.

2/Lt. 9-12-44 ... Capt. 5-11-57.

Son of Rawson Hart Boddam, BCS. and Ellen Kezia, his wife, dau. of J. T. Hungerford, solicitor of Bombay.

ed. by Dr. Thos. Firminger formerly of Greenwich Obsy., who prepared candidates for Haileybury[3], *DIB.* (146) [n. 453 n.10]; Addiscombe, 1843-4.

Conolly (106, 124).

April 1850, "entirely inexperienced in surveying operations on an extensive scale", and but recently arrd. in India, appd. to ch. topo. svy. in Gujarāt with half-trained pupils.

Jan. 1853, work abandoned on advice of SG., after failure to produce any svy. of value [192].

Later, Suptg. Engr., Saugor Div., PWD.

BRANFILL, Brydges Robinson. Ben. Cav.
b. 23-1-33. d. 26-5-1905.

Corn. 14-3-54 ... Bt. Col. 14-3-84; ret. as M. Gen. 10-11-84.

Son of Champion Edward Branfill, of Upminster Hall, Essex, Capt. 3rd Drgns., and Anne Eliza his wife, dau. of Rev. A. E. Hammond.

ed. Rugby, adm. Feb. 1848. Portrait, pl. 25.

arrd. India 24-6-54; regtl. duty, Ferozepore, Ft. Abazai, Sialkot; 2-6-58, on mc. to Murree with Peshāwar fever.

4-10-58, appd. to GTS. on Walker's recdn. joined him at Pindi 11-10-58; "I am very fortunate in having such a pleasant companion as Branfill, who is a man of great worth, and much liked and respected. I knew him very well at Murree. ... He is a man of sound judgement, with a good head on his shoulders. Unfortunately his education has been almost entirely classical, as he is a Rugbean, and it is not likely that he will be able to go far in mathematics. ...

"He is about 22 years old...but looks a much older man. He has plenty of energy and ballast. ... I was a little surprised at his volunteering, ...for I know he had more than one cavalry appointment open to him, with better pay than he will get with us [142]. Lieutenant Branfill threw up the adjutancy of his corps (now the 5th European Cavalry) in order to join the trigonometrical survey" [380][4].

1858-62, emp. on levelling; [53, 77-9, 399]. April-May 1860 Mahsūd expn. [217]; 1-5-62, tr. to Coast Series, on meast. Vizagapatam base-line; 1862-3.

1863-6, in ch. Coast Series to Madras and longl. series to Bangalore. Having trouble with eye-sight took furl. May 1866 to Jan. 1868; Aug. 1868 with Tennant obsd. solar eclipse nr. Guntūr; till 1876 on prepl. trgn. s. India, incl. meast. base-line at Cape Comorin and GT. connection to Ceylon.

1876-7, furl.; 1877-8, completed trgn. of s. peninsula; 1879-80, trgn. in Bombay, Sind, and Burma, with meast. base-line at Mergui, 1880-2.

Furl. from 10-11-82, pending rett.[5].

BROWN, John Read. Mad. Cav.
b. 6-7-05. d. 3-4-76.

Corn. 13-2-21 ... Bt. Col. 1-5-58; ret. as Hon. M. Gen. 31-12-61.

Son of Henry Brown, MCS., and his wife Ann, dau. of Richd. Sewell.

[1] DDn. 30 (1289), to SG., 4-11-62. [2] DDn. 624 (164), DSG. to SG., 5-4-56. [3] training coll. for HEIC. civ. services.
[4] DDn. 710 (231, 265), JTW. to SG., 23-10-58, 6-6-59. [5] *SI. Services*, 1-1-84; *SI. Notes*, 1-12-84.

m., Madras, 15-5-34, Margaret Mary, dau. of David Inverarity of Madras.

14-3-48, appd. to succeed Morland in ch. Hdbd. topo. svy.; took leave till assuming ch. 17th July [177, 287, 363, 428].

Two years later SG., pointed out that Brown had no previous svy. experience, and lacked "tact, patience, and conciliation", and was not "on friendly terms with the Brigadier commanding the district"[1].

The svy. was accordingly suspended from Dec. 1850 and Brown reverted to regt. [178, 384, 400].

BROWNLOW, Elliot Pakenham. Ben. Engrs.
b. 10-4-33. kd. in gunpowder explosion, Lucknow, 18-3-58; MI.

2/Lt. 12-12-51; Lieut. 21-11-56.

Son of Henry Benjamin Brownlow, BCS., and his 1st. wife, Amelia, dau. of Geo. Chester, BCS; bro. to Gen. Henry Alex. Brownlow, Ben. Engrs., Indian Rlwys.

ed. Addiscombe, 1850-1; SME. Chatham, 1852-3.

Blunt (236); Lang (1, 9, 12), portrait p. 7 [*inf*]; Conolly (92/284).

1853-4, Asst. Ex. Engr., 6 Div. GT. road, PWD.; 28-8-54 applied for appt. to GTS.

GO. GG. 4-2-56, appd. 2nd Asst. GTS.; posted to Kashmir Svy., joining at Dehra Dūn 28th Feb. Of his first season's work Montgomerie writes that "he assisted me during the first three months [May to July] so as to master all the details of hill surveying. Towards the end of the season [he] triangulated a portion of the river Jhelum [below Baramula] in a most complete manner. ... Showed great aptitude for hill surveying"[2] [225-6].

Nov. 1856, to Jogi-Tila ser. under Tennant [53], rejoining Kashmir Svy. May 1857. Took up recce. for trgn. w. across Kishanganga to Kāgān valley, but recalled after a few weeks to take over main trgn. as Montgomerie could not leave hdqrs. [227, 230, 515].

Reached Srinagar on 12th June, reporting that "although no geographical values have been obtained, ... the reconnaissance has not been without its uses. Eight staves have been erected on points which will prove useful next year, and... information has been obtained of a country hitherto but little known. Succeeded in making an accurate planetable sketch of that portion of Drawer...which is under the direct rule of the Maharajah, ... and which had never hitherto been visited by any European"[3].

Started out on 18th June to carry prinpl. trgn. N. from Hant HS. on ridge 15 m. N. of Wular Lake [226; pl. 6]. Much hampered by clouds and unfavourable weather, and had difficulty with supplies. Triangles lay across the inhospitable Deosai Plains, but from two stations he had a fine view of Karakoram Range, and took bearings from which Montgomerie was able to compute position and height for the great peak K 2 [88-9, 229, 232, 485, 514]. Closed work at station on left bank of Indus not far from Skardo and returned to Srinagar on 20th Sept., to leave again on 23rd to join army in front of Delhi, having volunteered for mil. service.

The SG. reported that "the successful result of Lt. Elliot Brownlow's operations proves him to be a thorough master...as a trigonometrical surveyor. .... As soon as his work was arrested...by the advent of snow [he] applied to me for leave to join the army at Delhi, which I granted. Eight days after receiving my permission [he] reached Delhi" [380, 399][4].

Reaching Delhi after its fall on 14th Sept., he accd. the Engr. Bde. under Alex. Taylor to Agra, Fatehgarh, and Lucknow.

18-3-58, died from wounds caused by an explosion at Lucknow, which occurred the previous day; "During the final reduction of Lucknow, a quantity of gunpowder in tin cases and leather bags was found in a yard. ... Outram directed it to be destroyed by the Engineers. It was taken to a large and deep well as rapidly as possible. When one of them was being thrown down it struck the side of the well and exploded. A flame of fire flashed up, igniting case after case, caught the powder in the carts, and blew it up, killing or severely wounding 2 officers and 14 men"[5].

"Inscription on monument in the enclosure of the tomb of Sa'adat Ali Khān at Lucknow" [483][6].

Tennant, who was with the Lucknow force at the time, writes that Brownlow was "always in front when wanted, willing, strong, and sharp. We have few who could adequately fill his place" [534][7]. SG. had already asked for his early return to the Kashmir Svy. "He possesses extraordinary aptitude, physical and professional, for mountain surveying, in which he has highly distinguished himself"[8].

The portrait here appended, from a daguerreotype of c. 1853, is reproduced by permission of the Society of Army Historical Research from their *Journal*, vol. IX, 35(7), of Jan. 1830.



[1] DDn. 542 (29), SG. to Mil Dept., 17-7-50. [2] DDn. 716 (65), to SG., 26-3-57. [3] DDn. 51 (34), EPB. to TOM., 13-6-57. [4] DDn. 643 (187), SG. to Mil. Dept., 15-10-57. [5] the other officer being Capt. A. J. Clerk, RE. [6] Blunt (236). [7] DDn. 715 (360), to SG., 16-3-58. [8] DDn. 643 (217), to Mil. Dept., 18-3-58.

BURGESS, Francis Jaques. Ben. Inf.

b. 1822; bapt. Barston, co. Warwick, 23-6-22.

kd. by mutineers, Jhānsi, 8-6-57; MI. St. James' ch., Delhi, & Saugor Gate, Jhānsi.

Ens. 11-6-42 ... Capt. 1856/7.

Son of Francis Burgess, barr. and Ch. Comnr. Police, Birmingham, and his wife Amelia.

Left a widow in England.

Blunt (155, 370-1); *Punjab Inscr.* (45).

Arrd. India Aug. 1842; 1843-6, regtl. duty, Bundelkhand; June 1847 to PWD., to lay out road to Saugor.

29-9-47, from cis-Sutlej svy. appd. asst. survr. rev. svy. Ajmer under Vanrenen; 1848-9, in ch. dett. on svy. round Delhi [6, 264-6, 324, 433].

In commending his technical work Vanrenen comments that "like most officers possessing a scientific knowledge of survey, he looks down with supreme contempt on revenue survey or circuit system. He takes little or no interest in matters connected with the revenue survey. ... He imagined he was best serving the interests of Government by giving up his undivided attention to the more scientific survey in the neighbourhood of Delhi than by giving up a portion of his time to Hoosain Buksh's jagheer survey [264, 451][1].

Season 1849-50, moved dett. to Bareilly and in 1851 given independent ch. of rev. svy. E. Rohilkhand [259-62, 498]. From 1853 moved his party first to Cawnpore, and then to start svy. of Bundelkhand s. of Jumna covering territories of Jaitpur and Jhānsi under PA. at Orai. [189, 267, pl. 16]. In course of this svy. he and all officers of his party were kd. by mutineers at Jhānsi Ft. [6, 267, 364, 396, 400, 483, 538].

DSG. reported that he was "a talented officer, and it is much to be regretted that his power of superintendence and administrative ability are not equally apparent. He is greatly wanting in...steadiness of purpose, diverting his attention to other pursuits not connected with the strict line of his duty, which suffers in consequence" [IV, 258-9; V, 267].

BURTON, Richard Francis. Bo. Inf.

b. 19-3-21. d., Trieste, 20-10-90.

Ens. 18-6-42 ... Bt. Capt. 18-6-57; ret. 1860/1.

Son of Lt.-Col. Joseph Netterville Burton of HM. 36th Ft.

ed. France and Italy and, in 1840, at Trin Coll. Oxford, being rusticated after a duel.

m., England, 1861, Isabel, dau. of H. R. Arundell, who shared his life in travel and literature; *DNB.*

KCMG. 1886. FRGS. 1859, with Founder's gold medal.

DNB.; *DIB.*; *Ency Brit.*; *Life* by Thos. Wright, 2 vols. 1906.

Oct. 1842, joined 18th BO. NI.; soon showed facility in oriental languages.

15-11-44, appd. asst. survr. Sind svy. in succession to Lieut. Dawson of HM. 86th Ft.; "His appointment...enabled him to mix with the people. He frequently passed as a native in the bazars and deceived his own *munshi*, to say nothing of his colonel and messmates"[2] [400].

Furl. 1849-53, making pilgrimage to Mecca; 1854, visited Somaliland; 1855, served in Crimean War with irregulars; 1856-9, on leave from India with Speke to sources of Nile. 1861, resd. Indian for Consular service, where he had even greater scope for travel and adventure. Prolific writer, incl. that of *History of Sind*; London, 1851.

CAMPBELL, Edward Fitzgerald. HM. 60th Rifles.

b. 25-10-22. d. 23-11-82.

2/Lt. 2-7-41 ... Maj. 9-9-58 ... Bt.-Col. 12-1-67.

Son of M. Gen. Sir Guy Campbell, CB., 1st Bart. and Pamela his 2nd. wife, dau. of Lord Edw. Fitzgerald; succ. as 2nd Bart. 1849[3].

ed. RMC., Sandhurst.

m., 25-10-53, Georgiana Charlotte Theophila, dau. of Sir Thos. Theophilus Metcalfe (1795-1853) 4th Bart., BOS.

2nd Sikh War, 1848-9; ADC. to Sir Chas. Napier, C-in-C., and then to Lord Dalhousie, GG., till 16-9-53, when nominated Asst. Rev. Survr. and posted to Bari *doāb* svy., acting in tempy. ch. from 5-12-56. "This officer, educated at Sandhurst, and possessing high qualifications as a draughtsman, was a great acquisition"[4] [400].

1857, to regtl. duty during Mutiny; at siege of Delhi; did not return to svy.

CARDOZO, Henry O'Connell. Mad. Svy., uncov.

b., Madras, 18-1-39.

d., pr. Rāmnād, 13-12-1906.

Mad Svy., Dep. Supt. 2nd cl., 25-2-59; ret. 1899.

Son of Benjamin Cardozo (1815-76), of Madras and Bath, England, and his wife, Bridget Margaret, dau. of Capt. G. O'Connell, Commy. of Ordnance, both of whom d. at Bath, MI., Locksbrook cem.

ed. Thorn Park, Teignmouth, Devon; Fellow, Mad. Univ.

m., 1870, Caroline Andrè. CIE.

Who was Who; Markham, 1st edn. (298); 2nd. (449); *Mad. Services.*

25-2-59, appd. 2nd asst. Mad. Rev. svy. Mslptm.; 1868, ch. No. 2 Party, Kurnool; 1869-70, furl. mc. to England; 1880 Bellary & Cuddapah [280, 445].

after rett., British Consul, Pondicherry.

COLEBROOKE, Robert Hyde. Bo. Inf.

b. 4-6-27. drowned nr. Poona, 3-10-49; MI. Wanowrie.

Ens. 13-6-46.

Son of Lieut. John Ulrick Colebrooke (1804-28), Mad. Inf., 2nd son of Lt.-Col. Robt. Hyde Colebrooke (1762-1808) SG. of Bengal [I: 326-9; II, 386-91]. John Ulrick d. after service in Burmese War 1824-6; his wid. Jane Maria Balfour living at Bath 1846.

ed. Grosvenor Coll., Bath, 1837-41, and King's Coll. New Brunswick.

22-7-48, appd. asst. rev. survr. Ahmadnagar, Geo. Anderson reporting, 6-10-49, that he died "in attempting to cross the Jamsetjee Bund near Poonah, the river at the time being high. ... A highly talented and promising young officer; was travelling from Ahmednuggur to Bombay on leave of absence" [400][5].

COWPER, Alexander. Bo. Engrs.

b. c., 1826. d., Simla, 16-6-68.

2/Lt. 13-6-45 ... Lt.-Col. 29-2-64.

Son of Lt.-Col. Thos. Alex. Cowper (d. 1825), Bo. Engrs.; Conolly (106, 34) and Charlotte his 2nd wife, dau. of David Maitland of Inverkeilor.

pr. father of M. Gen. Maitland Cowper, CB., Hodson's Horse.

Conolly (107/126). *Punjab Inscr.* (70).

arrd. India, Dec. 1846; with PWD. Upper Sind.

3-7-50 appd. asst. rev. survr., SMC.

May 1855, Supt. Rev. Svy., Khāndesh; 18-2-57. Supt. Rev. Svy. Gujarāt till Nov. 1859, when appd. Comdt. BO. S & M.; 1862, furl. [400].

Aug. 1864, to PWD. in ch. Mhow Div. Agra-Bo. Road; 1866, to Oudh; d. on leave in Simla.

Roorkee Papers, II, 1865 (57-75), paper on Mil. Bridges; III 1866 (184-212), on Bo. Rev. Svy. [IV, 239 n.1, 240 n.2]; Markham, 1871 (135 n.).

[1] DDn. 485 (A-17), Vanrenen to DSG., 1849. [2] *Ency Brit.* [3] Burke (366-7). [4] DDn. 624 (74), DSG. to SG., 5-4-56. [5] Bo. RC., 1849.

CREWE, Willoughby. Mad. Inf. & SC.
b. 25–2–20. d., Paris, 16–8–80.
Ens. 12–12–38 ... sc. 18–2–61 ... Lt.-Col. 16–7–64.
Son of Lt.-Col. Richd. Crewe and his wife Frances, dau. of J. Hare.
8–6–58, appd. Dep. Supt. 2nd cl., Mad. Svy.; 1870, in ch. Cuddapah and Kistna svy.; not on 1877 list [280, 401].

GORDON-CUMMING, William Gordon. Bo. Inf.
b. 2–6–29. dsp. 28–4–1908.
Ens. 12–12–46. ... Bt. Maj. 7–12–58; Maj. 12–12–66; ret. as Hon. Lt.-Col. 31–3–68.
son of Sir Wm. G. Gordon-Cumming (1787–1854) 2nd Bart. and Eliza Maria Campbell his wife.
m., 1st., 18–6–67, Alexa Angelina Harvey, dau. of James Brand of Balham, Surrey; she d. 8–12–93. m., 2nd., 18–4–95, Hon. Lettice Willoughby, dau. of 8th Baron Middleton.
Burke (566).
2–11–52, appd. asst. rev. survr. [400].
Auth. of *Wild Men and Wild Beasts*; pub. London, 1871.

DAY, Henry John [IV, 369]. Bo. Inf. & SC.
b. 30–1–19. d. at sea 7–5–75.
Ens. 30–1–19 ... sc. 18–2–61 ... Lt.-Col. 12–12–66.
Son of Henry Traningham Day, banker of Swaffham, Norfolk, and his wife Mary.
m., Ahmadnagar, 27–1–48, Georgiana Eliza, dau. of M Gen. J. H. Dunsterville, Bo. Inf.
30–8–41, appd. to Nasik Rev. Svy.; 1842–3, mil. duty; 18–5–43, rejoined at Nasik; 1846 to Ahmadnagar; 1848–52, to mil, duty [401].
18–10–52, asst. Deccan rev. svy.; April 1856, so. with rev. settmt. Upper Sind [278]; Sept. 1857, resd. for ill-health.

De LISLE, Alfred. Bo. Engrs.
b. 18–1–23. d. 3–4–99
2/Lt. 10–12–41 ... Lt.-Col. 18–2–61; ret. as M. Gen., 12–5–68.
Son of Ferdinand De Lisle, merch., of London, and his wife Elizabeth.
Conolly (106/118).
1–10–49, under CE. Bombay, took over ch. from Capt. Crawford as Supt. Svy., Canal, & Forest Dept., Sind; endeavoured with small staff available to set both rev. and topo. svys. on sound lines, but dept. abolished April 1850 [193, 276]. MRIO. 120 (13), Map of part of Lower Sind, 4 m. to inch [193 n.6, 277n].
1860, Dep. Cons. Engr. Rlwys., Karachi and successful career engr. services, Sandes, II [40, 179].

DENNYS, Julius Bentall. Ben. Inf. & SC.
b. 21–1–22. d. 25–5–1907.
Ens. 3–1–40 ... Maj. sc. 18–2–61 ... USL. 1881; Lt.-Gen. 14–1–87.
Son of Nicholas Dennys, wine merch. of London, and Elizabeth Mackay his wife.
m., 9–8–45, Harriot, dau. of Tunus A. Vanrenen (1793–1836), Ben. Art., Hodson, IV (344), and sis. to Donald [538–9].
Who Was Who.
Afghān War, 1841–2, under Nott.; 1st Sikh War, 1845–6; comdg. Kotah Cont., 1853–8.
20–10–54, without previous svy. experience, but with influence of his bro-in-law Donald Vanrenen, appd. to ch. Jāwad-Nimach rev. svy., raising party from Vanrenen's unit in Naini Tāl. With able asstce. of Edw. Johnson completed svy. by Feb. 1856 reverting to comd. Kotah Cont., 1–11–56 [266, 364, 396, 400, 505].

DEPREE[1], George Charles. Ben. Art. & SC.
b. 2–8–32. d., Jersey, CI., 18–2–87.
2/Lt. 14–6–50 (9–12–50) ... Capt. sc. 24–3–65; Maj. 9–12–70 ... Bt.-Col. 1–7–81.
SG.; offg. 12–2–83; cnfmd. 12–1–84.
Son of George James Depree (d. 1849), London wharfinger, and his wife Lucy, dau. of Chas. Saxton and sis. of Geo. Harper Saxton (1820–1901), survr. [525–6].
ed. under his uncle, Dr. C. W. Saxton, DD., at Wem, Salop, and then at Adams' Grammer Sch., Newport, Salop; Addiscombe from Feb. 1848.
m., Edinburgh 22–2–70, Mary Elizabeth, eldt. dau. of John Haig of Cameron Bridge, co. Fife, and sis. of Douglas Haig, FM. and 1st Earl (1861–1928); she re-m. c. 1888–9 John Jameson of St. Marnocks, co. Dublin.
Their eldt. son, Hugo Douglas, b., Mussoorie, 25–12–70, ed. Eton, became Col. Comdt. RA., CB., CMG., DSO.; was Comdt. RMA. 1926–30, and d. March 1943 [497].
Portraits in oils by G. G. Palmer [536 n.1] GBO. Lib. [pl. 24];—from family photo. [pl. 26].
Arrd. India 18–6–51; leave from Dum Dum 28–6–to 15–11–51; Dec. 1851, with fd. force to Arakan; survd. Kyaukpyu city; Jan. 1853, sketch and report on Taungup pass for passage of 150 elephants for Prome, receiving thanks of GG in C.[2] [194]; from 30–11–53, Asst. Ex. Offr., Chittagong-Arakan Rd.; sick leave to Ootacamund, 17–6 to 5–12–54.
25–7–54, applied. for appt. as asst. to his uncle Geo. Saxton in Orissa, being "acquainted with the use of the theodolite, level, compass, etc, and the practice of common field surveying" [386].
GO. GG-in-C., 20–10–54, appd. asst. to Saxton "now employed in the survey of the South-West Frontier, Tributary Mehals"; reaching Calcutta 4th Dec. he joined party just before it took fd. on 18th. After a few weeks recording for Saxton, and obsg. himself with 5-inch theodolite, made 3-inch svy. round Sambalpur. Saxton reported, 27–4–55; "I congratulate myself and the Department on the acquisition of Lieut. Depree's services. He has been most zealous and in every way efficient. His health has remained good under exposure, etc., which are a severe test, and he likes the work [4, 28, 171–4, 421]"[3].
In letter to his mother written from recess qrs. at Cuttack, 19–8–55, reports death of Saxton's wife [526] and continues, "The...boxes arrived while Uncle George was away on the river, and I was very much pleased to receive mine. One of the pots of jam was unfortunately broken the day before reaching Cuttack. ... You may imagine the state of the papers and tracts. Not one of them of course is readable, being saturated with jam. ... The socks will be splendid for the next jungle season. ...
"My watch did not arrive. I wrote to my Agents to tell them to get it, ... and they write back that it had not arrived, but would probably do so by the next steamer. ... It is very inconvenient to be without a watch [IV, 373]. Uncle George's chronometer just come out from Alderman Carter has stopped and is useless[4]. ...
"We are anxiously expecting further particulars of the late reverse before Sebastopol. It is dreadful to contemplate the loss of life which occurs in each fortnight. ...
"I see by the Gazette that the Pegu medals have arrived at Madras, so I suppose they have in Calcutta too, so I may expect mine within a month or so. ...

[1] one word, without accent, rhyming with "three" [496]. [2] DDn. 644 (130), from QMG. Ft. Wm., 6–4–53. [3] DDn. 593 (609), to DSG. [4] Alderman John Carter (d. 1878); clockmaker of 61 Cornhill, London; later Lord Mayor.

"My two servants whom I brought down with me from Calcutta I have been obliged to send back as they have been constantly suffering from fever ever since the last jungle season. ... Everyone in the house except myself have been unwell this last week, and I thought fever was coming on; however they are all better now except Uncle George' [364]".

When Saxton took furl. in 1856, the SG. asked Strange, now in ch. of Coast Series, to keep general control of the topo. parties under Depree and Dyer who would be recessing with him at Cuttack, and at the same time he wrote a kindly letter to Depree to soften any resentment. Strange wrote warmly of Depree's work [291, 370, 377–8, 386].

Season 1856–7 was a particularly unhealthy one, and Depree succumbed to the general fever. To give him an opportunity of regaining health and acquiring wider experience, Waugh suggested his transfer to the Kashmir Svy. with a few of his assts. for summer months, but neither he nor his assts. were fit enough for the journey [464–5]. At the end of 1858 he again declined transfer to Kashmir. Though he would personally like it, his party doctor insisted on a change to Europe [175, 367][2].

Jan. 1859 to April 1860, on furl. in England, taking opportunity to visit os. offices at Southampton to master technique of litho-printing, on which he reported to SG. [331] who, on greeting his return to duty hoped that he was still "a bachelor, a state best suited to the conditions of a surveyor's and soldier's life, especially in these uncertain times when our future...prospects are so doubtful"[3].

Reported for duty at Calcutta, 3-4-60, and moved his party into Chota Nāgpur the following season, [176, 184, 244, 387, 399, 422, 519][4].

He held ch. of his old party, now No. 4, till 1877, working through Rewah into CP.; took two years furl. from Dec. 1868, and this time returned with a wife. The party was disbanded Oct. 1877, and he took ch. No. 7 Rājputāna, with recess qrs. Simla, making topo. svy. Bikaner cants., Sabāthu and Kasauli, and Simla roads [400].

Furl. again Dec. 1881–2, being appd. DSG. Topo. Svy. from 1-1-83, and offg. SG. from 12-2-83. He held post of SG. till he took 7 mo. leave on mc. from 7-3-86, that was twice extended [526–7].

Following Walker's 15 y. tenure of the combined offices, Depree's long service in topo. surveys did not lead him to close sympathy with the interests of the GTS.; he questioned for instance the propriety of Hennessey spending the rains in Mussoorie whilst his staff carried on at Dehra [502]. His attitude was possibly that of his son, Gen. Hugo, Comdt. RMA., of whom it is told—A Cadet was on the mat for poor progress in science and "the old man remarked that he had never been able to understand the stuff himself".

He introduced the pubn. of monthly *Survey Notes*, starting with the issue of 1st May 1884.

There has been some uncertainty about the spelling of his name. After 1880 our surveyor changed spelling from Depree to De Pree after his discovery that his father came from the aristocratic family of de Prie, one or more of whom escaped from France during the revolution at end of 18th century. From 1882 to '86 the deptl. svy. lists showed an accent that was also current in the family with pronunciation "pray" up to about 1920. However at the Shop 1926–30, Gen. Hugo's name was always rhymed with "three".

The suspicion of an accent in the signatures on plates 9, 24 and 26 is in reality a flourish over the "r" which appears through all his writing.

DU VERNET, James Smith [III, 440–1; IV, 432–3].
b. 26–4–03. d. 2–11–72. Mad. Inf.

Ens. 2-5-23 ... Bt. Maj. Nov. 1851; Bt. Lt.-Col. 4–11–56; ret. 21–4–57.

Son of Lt.-Col. Abram Du Vernet, RA., and Miriam his wife. m., Truro, 20–8–38, Eliza Lavinia, dau. of Benjamin Martindale of Brunswick Sq., London.

"The best draughtsman of his day at Sandhurst"[5].

1824, arrd. Madras; 1828–32, asst. Mad. topo. svys.; 1832–6, ch. Hdbd. Svy.; furl. 1836–9 [III, 342; IV, 361; V, 177, 290, 346, 384].

18–3–40, nominated 2nd Asst. GTS.; promoted to 1st Asst. 14–6–44; ch. N. Longl. Conng. series 1841–4; Karara, north, 1844–5; Gurwāni, 1845–7 [11–2, 16, 18, 21, 81, 86, 92, 119, 184, 361, 366, 399].

1845, "having suffered severely from jungle fever...whilst finishing the northern part of the Karara Series, ... was away on sick leave to the Mussoorie Hills for three months during the recess of 1845, and only returned to the Surveyor General's headquarters at Allahabad on 15th September when he received charge of the Gurwāni Series" [368].

He completed this series by May 1847, winning high praise from SG. who now selected him for ch. of the new Punjab series running west from Dehra Dūn along the lower Himālaya [34–6, 98, 113, 115, 149, 153, 156–7, 200–4, 385].

Oct.–Nov. 1848, held up by Sikh rising in Hoshiārpur Dist., and again in March 1850 by trouble over Trikota hill [35–6, 472–4]. From Oct. 1850 handed over ch. of prcpl. trgn. to Logan and took ch. of topo. svy. of hill region extending from Simla to Chamba [2, 4–5, 36, 162, 200–7, 282–3, 286, 377].

About Aug. 1852, having declined offer of ch. Hdbd. topo. svy. [178, 393, 395], selected for ch. of new longl. series into Assam, and protested strongly;

He had led his party "into the Upper Himālaya ranges above Kangra and Chini, through the Spitti valley into Lahoul, and to the Ladak and Chinese boundaries, returning ...through the very mountainous district of Pangai...into the lower Chamba and Kangra.

"In the seasons 1851 and 1852, I had topographically surveyed all the tract between the Jumna and the Ravi, bounded northerly and westerly by the Maharajah Golab Singh's territory and China, with the exception of a portion of Chamba of which the survey was in progress. For the season 1852 and 1853, there remained the whole of the Tiri district between the Jumna and the Siwalic Range, with the Siwalic Range and the Ganges to be surveyed. ... My field work was not finished [202–7]"[6].

He had perforce to comply with orders[7], and leaving family in Mussoorie took over ch. of Assam party 1st Jan. 1853, at Rāmganj near Jalpaiguri [29–30, 155, 163, 337–8, 461, 476; pl. 28].

The SG. met him at Jalpaiguri at the end of the month and a bitter corr. was kept up on the subject of this transfer which the SG. eventually forwarded to Govt. and obtained their disapproval of the "insubordinate and disrespectful language which Brevet Major Du Vernet has addressed to yourself, ... any repetition of which...will certainly cause his immediate removal from your Department [393–5, 541]"[8].

From this time on he could do nothing right Waugh disapproved of his recessing at Dacca, so far from field work, a choice which Du Vernet justified at length [369]. Waugh was dissatisfied with the

[1] Family papers. [2] DDn. 664 (356), Depree to SG., 11-12-58. [3] DDn. 4 (57–62), 22-3-60. [4] wrongly shown as Capt. No. 4 party on reverse plate 9, survd., 1855–7. [5] DDn. 462 (100), SG. to Mil. Dept., 12-2-47. [6] DDn. 606 (153), to SG., 10-2-53. [7] DO., 19-10-52. [8] DDn. 546 (225), Mil. Dept. to SG., 10-6-53.

slow progress of trgn., and called for copies of his angles which were found far below the standard of accuracy required [116, 394].

This reopened the exchange of unhappy letters, which Waugh closed by reporting to Govt. that "on examining his observations I found them so full of discordancies as not only to be inadmissable...to the present standard, ... but... to justify the conclusion that his physical qualifications as an observer had become impaired".

Du Vernet protested that he was being unfairly judged, but the SG. now reported that he had found his obsns. on the NW. Himālaya ser. failing in accuracy; "This was my chief reason for relieving Major Du Vernet from...geodetical duties, and employing him in topographical details. ...

"Major Du Vernet, having previously served creditably as a topographical surveyor, joined the Trigonometrical Survey late in life. My predecessor found it extremely difficult ...to inculcate those sentiments of refinement and accuracy which are indispensable to render a trigonometrical survey of lasting value [IV, 357, V, 379, 381–2]. ...

"I took great pains to elevate Major Du Vernet's ideas. ... From 1844 to 1847, but particularly in the two latter years, his work gave me satisfaction. ... Latterly, however, I...found his work gradually deteriorating. ... His observations are...unfit for any work of high order. ... [He] cannot be any longer employed on the Trigonometrical Survey of India with any advantage to the State[1]".

Whilst orders of Govt. were awaited, Du Vernet was allowed 3 mo. leave to Mussoorie "to join Mrs. Du Vernet on account of her delicate state of health"; a dau. had been born in April 1853 [393 n.2]. He submitted his resgn.

"Believing...that my further stay in the Department under the present Surveyor General is not likely to be attended with advantage to the State, or benefit to my reputation—smarting...under the language used to me, and under trials and accusations which...my pride finds hard to bear—I solicit your Lordship to allow me to retire from it. Yet, if 25 years passed in lonely and laborious employment, often of great exposure, always of great anxiety, may...allow, ... I may be employed in such other manner as...will save me from... compulsory return to my regiment in the Madras Presidency[2]".

His resgn. was accepted, and he was tr. to Pegu for empt. in ch. of Telegraphs under the CRE., joining in March 1854 [141, 395, 399][3].

EDGECOME, William Henry. Mad. Engrs.
b. 3–4–32. d. 31–8–1906.
2/Lt. (12–5–51) 12–12–51 ... Lt.-Col. 17–8–77; ret. as M. Gen. 24–1–85.

Son of Dr. Geo. Evans Edgecome of Mad. Med. and Eleanor his wife.
Conolly (101/206).
27–10–54, offg. Ex. Engr. Bassein, Burma.

Sept. 1856, from engr. duties in Pegu, appd. asst. Pegu svy., and succ. Williams in ch. [196–7, 199, 543]; 16–12–59, resd. ch. to Fitzroy and after furl. on mc. became Principal of Civ. Engrg. Coll. Madras, till re-appd., 16–3–65, to ch. Pegu Svy., assuming ch. 29–4–65 [498]; closed fd. work and left Rangoon 18–8–65, completing maps at Madras, and submitting them in Oct. 1867 [384, 400, 447, 498].

ELLIOT, Minto. Ben. Art.
b. 23–9–33. d. 14–3–1909.
2/Lt. 11–6–53 ... Bt.-Col. 31–12–82; ret. as Hon. M. Gen. 1887.

Son of Edw. Eden Elliot, BO. CS., Acct. Gen.
ed. Addiscombe.
m., 1857, Amelia, dau. of Geo. Martin.
Who Was Who.; CB. 1907.
1857, siege of Delhi; appd., pr. 1858, asst. rev. survr., Bari *doāb*; with Hunter Thompson left Simla, 1–12–58, for Hazāribāgh to start rev. svy. Chota Nāgpur [244]; resd. 1–5–59 [400]. Later had distinguished mil. career.

ELPHINSTONE, Percy Augustus. Bo. Inf. & SC.
b. 27–9–28. d. 3–5–89.
Ens. 3–2–47 ... Lt.-Col., sc., 3–2–73; ret as Col. 4–5–74.

Son of Alex. Fraser Elphinstone, Capt. RN., a noble of Livonia, Baltic States, and his wife, Amelia Ann, dau. of A. Lobach, of Cumenhoff, nr. Riga.
30–1–52 (1–7–52) appd. asst. rev. survr. Ahmadnagar; 1858, Khāndesh; furl. for 15 mo.; Markham, 1871 (299), Settmt. Offr. Berār; 4–11–72, furl. for 18 mo. [400].

FITZGERALD, Martin Frederick. Ben. Inf.
bapt., Kidderpore, Calcutta, 15–2–29.
lost at sea, 8–5–52, from ss. *Favourite*.
Ens. 13–12–45; Lieut. 8–4–50.

Son of Maj. Wm. Robt. Fitzgerald [1798–1844], Ben. Engrs. [III, 448], and his wife Sarah, dau. of Robt. Fulcher[4].
GO. 13–11–50, appd. asst. rev. survr., and joined Bari *doāb* svy. 23–12–50. Leave on mc. to Australia 6–7–51. "He has never been heard of since, and was supposed to have been lost at sea on his return passage [400]"[5].

FITZROY, Ferdinand. Ben. Art.
b. 15–6–33. d. 11–9–1907.
2/Lt. 9–12–52 ... Maj. 5–7–72; ret. as Lt.-Col. 22–9–75.

Son of Wm. Simon Houghton Fitzroy, of Kempston, Norfolk, and Anne, dau. of Thos. Bagge, of Stradsett Hall, Norfolk.
ed. Bedford Gr. Sch.
m., 18–9–55, Mary Helena, dau. of Maj. G. R. Crommelin (1803–44), Ben. Cav.; bro. of J. A. Crommelin, Ben. Engrs. [III, 435]. Hodson, I (414–5).
26–9–56, appd. asst. survr. Pegu Svy., taking ch. from Edgecome 16–12–59 [*sup.*].

The Pegu Svy. had from its start been carried on by officers without previous svy. experience, and with no prof. control. It was based on a system of intersecting traverses, without scientific closing of circuits [297–8]. Though said to be 9/10ths complete when Fitzroy took ch., he had started revision of the traverse system, and in many parts an entire new svy. In 1863 the svy. was for the first time put under control of the SG., and Thuillier was horrified by Fitzroy's reports [196–9 384, 400].

He questioned the irregular methods of both svy. and mapping, and disapproved Fitzroy's failure to keep the Pegu authorities aware of his difficulties. Fitzroy expressed resentment at criticism, and met stern rebuke;

"The tone and style of both documents are highly objectionable, and such as cannot for a moment be tolerated. ... Unless you withdraw and apologise ... and reply to the questions...in a becoming manner, it will be my duty to submit the papers for the orders of the Government of India."

Fitzroy made a halfhearted apology and the whole case was put up to Govt. In Dec. 1864 he applied for leave on mc. which recorded that he had been "resident in Burma 11 years plus—habits temperate and very regular—habit of

[1] DDn. 547 (187), to Mil. Dept., 8–10–53. [2] DDn. 606 (173), to Mil. Dept., 7–11–53. [3] *Tel. Report* 1855–6 (CXXI), Du Vernet reports constrn. of telegraph lines in Pegu. [4] pr. sister to Robt. Page Fulcher who m. wid. of Colin Mackenzie [III, 474]. [5] DDn. 624 (57), DSG. to SG., 5–4–56.

body spare—temperament nervous—Has been under my observation from August 1862 to present date, during which period I have scarcely known him to enjoy one day's good health, suffering constantly from dyspepsia and all its concomitants"[1].

16-3-65, granted furl., and Edgecome was called in to wind up svy. and complete the maps [199, 497]. Thuillier refused to employ Fitzroy in the svy. dept., but added that "there is nothing whatever against his character as an officer to prevent his being again employed in any other department".

At the end of 1866, Col. Walker when actg. SG. took the opportunity to see both Edgecome and Fitzroy at Madras. Fitzroy was deeply grieved at the slur that had been cast on his prof. conduct and ability. He had even been removed from a troop of Horse Artillery to a Garrison Co., where pay and allces. were smaller. He pressed for further svy. empt.

"Enough has been said [writes Walker] to show that the work executed under...Capt. Fitzroy is of a superior quality to what had been executed by his predecessors. Having had an opportunity of inspecting Captain Fitzroy's records... I can testify to the scrupulous care with which they appear to have been prepared, and their methodical and skilful arrangement. ... Capt. Fitzroy has laboured with great assiduity and devotion, and...possesses many excellent qualifications which should enable him to do good service... in some other department than the Survey.

"Unquestionably he committed a grave error of judgement in making a resurvey of the Province...without either soliciting or obtaining the authority of Government to do so. He still maintains that a resurvey was absolutely necessary, and that the previous survey was useless. ...

"In Capt. Edgecome's hands the original survey would have been worked up and put together so as to form a fair geographical map...which would have answered all the immediate requirements of the public service. ...

"The first result of Capt. Fitzroy's measures was to prolong the operations. This gave rise to enquiries on the part of the Chief Commissioner, who ordered a Committee of Enquiry. ... Instead of Capt. Fitzroy...displaying the slightest readiness to assist the Committee, ... his conduct was such as to...frustrate the objects which they had been directed to carry out. This went on for upwards of a year, and at last, when the Chief Commissioner and the Committee found him utterly unmanageable, he was placed under your [SG.'s] orders [197].

"He completely exhausted your patience...by...letters which, while they failed to convey any distinct idea...of his operations, were neither conciliatory nor respectful, and eventually compelled you to the reluctant conclusion that the...uncontrolled action which Capt. Fitzroy had previously enjoyed now unfitted him for further employment in the Survey Department. I cordially agree"[2].

Walker repeated that he could not recommend Fitzroy for empt. in the svy. Dept.;

"He has never received any training in this Department, of the duties of which he knows little or nothing. ... He is so self-opiniated as to assert of his work that...'no other survey in India can be mentioned which has surpassed or even equalled the results'. Holding such sentiments it is clear that if he were again employed...he would probably be as...unamenable to the authority of the Surveyor General as...when he was first placed under your orders"[3].

FORLONG, James George Roche[4]. Mad. Inf.
b. 6-11-24. d. 29-3-1904.

Ens. 30-12-43 ... Bt.-Col. 30-12-74; ret. 20-7-76; Hon. M. Gen. 28-10-76.

DIB. Prolific writer on Indian religions and folklore, archæology, and philology; *Roorkee Papers*, IV, 1867, (140-2), OXL, *Bricks.*

Burmese War, 1852-3; made various route svys. Arakan Yoma and Tenasserim [195] 1854-61, Supt. Pegu and Arakan roads, PWD; SE. Bengal to Rājputāna, 1861-71; CE., Oudh, 1872-7.

FRANCIS, John Thomas [IV, 369]. Bo. Inf. & BO.
b. 16-2-19. d. 4-8-96.

Ens. 12-1-41 ... Lt.-Col. 12-1-67; USL. 1-7-81; M. Gen. 31-3-92.

Son of Benj. Francis of Twyford Guist, Norfolk.

m., Dhārwār, 13-9-47, Georgina Anne, dau. of late Lieut. Geo. Frankland, of HM. 55th Ft.; she d. 1887, aged 63.

8-12-42, appd. asst. rev. survr. SMC.; Aug. 1850 to ch. Deccan rev. svy., Poona, and Supt. Rev. Svy. & Assmt.; Aug. 1859, in ch. Thāna Rev. Svy. [398, 401].

Markham, 1870 (299), Supt. N. Div.[5]; 1871, Svy. & Settmt. Comnr. Poona & Nasik; 1876, furl.

FULLER, Abraham Richard. Ben. Art.
b. 12-11-28. dro. nr. Barakao, Rāwalpindi, 20-8-67; MI., St. James' ch., Delhi.

2/Lt. 14-6-45 ... Capt. 29-6-41.

8-11-53, appd. asst. rev. survr. under Burgess in Rohilkhand, and with him to Bundelkhand [267, 400].

May 1855, resd. to become Inspr. in Education Dept.; 1857, to tempy. mil. duty; dro. on road to Murree.

GARFORTH, Peter. Ben. Engrs.
bapt. 14-1-21. d., Yorkshire, 2-10-58.

2/Lt. 11-6-40 ... Capt. 23-1-55; resd. 3-12-55.

Conolly (89/208).

Son of James Braithwaite Garforth of Coniston, Westmoreland, and his wife Frances Catherine.

m., 19-6-56, Frances, dau. of James Hamerton, JP., DL., barr.; she re-m., 1866, Rev. John Stansfield, of Coniston, and d., 1884, aged 63.

GO. 13-10-43, appd. 2nd. Asst. GTS., but posted to Army of Gwalior, joining Chendwar ser. under Logan March 1844 [382].

18-7-44, to ch. Gora ser.; much delayed by sickness in Kaimur Hills, 1844-5 [12, 457, 476]; recessed at SG.'s hdqrs., Allahābād [130, 156, 161, 163, 361, 368]; made good progress 1845-6, staying out till 25-8-46, much against SG.'s wishes; "I fully expected your arrival at my office before the end of last month. ... Your further continuance...in the field at this season is for many reasons to be deprecated. ... The result cannot fail to be prejudicial to the organization...and prove an inconvenient innovation. ... You are hereby directed to join my headquarters with all practicable despatch [12, 365-6]"[6].

He completed the series during season 1846-7, and then resd. 1-9-47, being posted to S & M., Meerut from 30th Sept. [379, 399, 415].

Sept. 1848, wounded at siege of Multān.

GARNETT, Arthur William. Ben. Engrs.
b. 1-6-29. d., Calcutta, 1-5-61.

2/Lt. 12-6-46 ... Capt. 27-8-58.

Conolly (91/248).

Feb.-June 1849, with Walker on Peshāwar svy. [214]; to Kohāt [215]; *IO Cat.* (467), with Lumsden, 1855-6, on svy. Kurram valley; *RGS. Progs.*, 32, 1862 (304) [215 n.1, 217].

[1] DDn. 55, SG. to Fitzroy, 29-3-64; reply 6-7-64; mc., Rangoon, 21-12-64. [2] *GR Trig. & Topo: 1864-5* (14-6); DTW.; 19-7-66, DDn. 7 (182), STS. to SG., 16-1-67. [3] ib. (193-4), 16-5-67. [4] not Rorke as in *DIB.* [5] North Div. covered Colaba, Thāna, and all dists. to N; *IO Cat.* (436). [6] DDn. 492 (117-8), 8-8-46.

Roorkee Papers, I (227–44), XXV, account of Kohāt Ft.; Ex. Engr. Kohāt.

GASTRELL, James Eardley. Ben. Inf. & SC.
b. 18–1–19. d. 29–8–94.
Ens. 11–12–35 ... USL., 1–7–81; Gen. 23–1–89.

Son of James Gastrell, merch. of Bristol, and Charlotte his wife.

ed. as civ. engr.

m., 10–12–45, Miss Kate Sullivan who d., Bedford, 6–3–1917 aged 90.

Ubique, mil. service, Jeypore, 1838; Bdlkd. 1842–3; 2nd Sikh War, 1848–9, Chiliānwala and Gujrāt, sub-asst. commy.; *SI Lists.*; auth of *Geogl. & Statl. Report, ... Jessore, ... Backergunge* Calcutta 1868.

14–10–51, nominated asst. rev. survr.; GO. 13–1–52, appd. to Bari *doāb* svy.; took ch. from John Blagrave 30–8–52; leave to Naini Tāl; asks DSG., for tr. 16–11–53; "Naini Tāl empty, and I am wofully tired of being idle and having nothing to do"; to Bengal, GO. 23–11–53.

to DSG., Benares, 21–12–53; "I have been here since the 19th, and am looking out for the down steamer, *Jumna*, expected here every hour, to get on board and proceed to Bogwāngola. Sherwill advised so strongly against the land journey that I altered my intention of going dawk. He tells me no palkee to be had in the jungles at Mungalpoor.

"Delayed at Meerut awaiting my remittances. ... After getting away from there, I experienced but one delay from the wheel of the carriage breaking at Cawnpore. Fortunate it was...that it lasted until I arrived at the station.

"Coming down country one is struck with the increase of comfort and goodness of houses, etc., in contrast with the wildness of the North-West. If we could but have the cold weather of those provinces, lower India would be perfect.

"I enquired at Allahābād and Cawnpore for letters, but found none from you, ... from which I conclude that Government will not sanction my expenses being paid down. ... I hope to be at Bishanpoor in another 4, 5, or 6 days, unless we stick on the sands going down"[1].

6–1–54 at Berhampur took over ch. from Walter Sherwill of No. 4 Div., Murshidābād [241].

9–8–55, handed over ch. 9–8–55, to join mil. unit in campaign against Santāls [491], writing, 26–12–55, from Nāya Dumka; rejoined svy. 23–1–56 [372].

15–10–58, appd. Rev. Survr. on full allces. working w. through Jessore into Bākarganj [6, 243, 255–6, 364, 396–7].

He writes of the Sundarbans tigers; "The inhabitants of the villages on the confines of the jungle complained bitterly of the constant attacks made upon them and their cattle by tigers. Many ryots, they said, had recently left the clearings in consequence, and more talked of soon doing so. In several places the villagers guarded the doors of their huts at night with strong nets to prevent the ingress of these animals, and they declared several persons had latterly been carried off for want of this due precaution [255–6]"[2].

13–5–62, succ. Sherwill as Bdy. Comnr. "for adjustment of the new Civil & Criminal jurisdictions in Bengal and Behar"; hdqrs. at Calcutta, holding ch. SGO. during SG.'s absences on tour [257].

11–3–67, DSG. & Supt. Rev. Svy.[3]; 1868–9, ch. SGO. at Calcutta, during SG.'s absence; furl. for 2 y. from Dec. 1869; 1876, Supt. Rev. Svys. Upper Circle, Allahābād; 25–1–77, furl. on mc. till ret. [400].

A most capable rev. survr., who introduced numerous reforms, and one of the leaders in new system of "cadastral surveys" [10, 321].

GRANT, John Hayes. Ben. Art. & SC.
b. 8–2–30. d., Hastings, Sussex, 12–11–68.
2/Lt. 10–12–47 Capt. BSC., 18–2–61 ... Maj. 10–12–67.

Son of John Grant, Presdcy. Surg., Calcutta, and his wife Elizabeth Nicholson Agnes Hayes.

m., Simla, 17–9–55, Georgiana, dau. of C. Vaughan.

18–3–56, nominated asst. rev. survr., joining Vanrenen's party at Jubbulpore, 8th July; promoted Rev. Survr., 23–4–58; to offg. ch. No. 2, or W., Div., OP., 1860 to 5–12–63; reverting to mil. duty 28–12–63 under GOGG. of 5–12–63 [268, 398, 400].

1866 with regt.; 1868, furl. on mc.

GUSTAVINSKI, Louis Thomas Kough. Ben. Inf.
b., Waterford, Ireland, 26–5–34.
d., Lakhimpur, Oudh, 6–3–67.

Sub-asst. Punjab Rev. Svy., 1–1–50; resd. 1854; Ens. HM. 95th Ft., 3–2–60; Lieut. 2nd. Punjab Inf. & SC. 18–2–61.

Lang (20 n., 96, *et passim*): Sandes, I (231); *G R Rev. 1866–7* (5).

Parentage unknown, though father was obviously a Pole; no infn. found from Irish records.

The portrait here reproduced, with permission, from p. 83 of *Journal of the Society for Army Historical Research*, was originally taken from water-colour by Swedish artist Egron Sellif Lundgren (1815–75), *DNB.*, who accd. Sir Colin Campbell's column in Oudh 1857. His numerous sketches were sold by auction in London in 1875, and this portrait is now in possession of Lord Wyfold at Sarsden Ho., Oxon.



L Gustavinski
24th Proj: Infty

[1] DLR. 37/59 (39–40); Bhagwāngola, 10 m. above Murshidābād, or 15 above Berhampore. Gastrell (24). [2] DDn. 493; Qn. Reports, Wazirābād. [3] after actg. from 24–7–65.

11-1-50, appd. sub-asst. rev. svy. Jullundur *doāb*; 1851, with party to Rechna *doāb*, Thos. Blagrave reporting, 5-12-53, that "he is the best sub-assistant I have; has worked so diligently and willingly as to have qualified himself for the charge of a camp"[1].

resd. 1854 for empt. on canals, being at Lahore in 1857 as Asst. Engr. on Bari *doāb* canal[2]. Held tempy. comn. with co. of Mazhbi Sikhs to siege of Delhi[3], and so distinguished himself there and at capture of Lucknow that he was comnd. to HM. 95th Ft.

He tr. the following year, 1861, to 2nd Punjab Inf.; Jan. 1867, appd. asst. rev. survr. in Oudh, Anderson reporting two months later;

"I started Lieut. Gustavinski on his purtal...on the 2nd Feb. ... After...initiating him in the method of purtalling... I left him proceeding to Luckheempur where Camp 2 was located, examining his work there. ...

"On the 24th Lieut. Gustavinski reported that he was unwell, and had gone into Luckheempur for medical treatment. ... I have since received the report of the death of this officer. ... [He] promised so well, being a zealous, anxious, and conscientious worker"[4].

The medical report showed that he had died "on the 6th day of March from diphtheria...after a severe attack of remittent fever".

HAIG, Charles Thomas. Bo. Engrs.
b. 12-10-34[5]. d. 29-6-1907.
2/Lt. 8-6-54 ... Lt.-Col. 23-1-77 ...
M. Gen. 19-2-87; furl. 30-11-88; ret. 1-4-91.

Son of Thos. Haig of Bonnington and his wife Charlotte, dau. of Robt. Haig of Roebuck; 1st cous. to Malcolm (*inf*).

m., 22-11-64, Katherine, dau. of John N. Walker, of Bedford; their dau. Gertrude Ellen m., Dehra Dūn, 25-4-87, Sidney Gerald Burrard (1860-1943), RE., SG. 1910-19.

Conolly (108/161); *Burke's LG.* 1937 (100); *Who Was Who.*

arrd. India, July 1856; with Bo. S & M. Persia, 1856-7; Rājputāna fd. force, 1858-9. May 1858, appd. Asst. Ex. Engr., Nimach. FRAS. 1868.

22-9-59, appd. 2nd Asst. GTS.; 15-10-59, joined Bombay party under Nasmyth at Rājkot; with Okhamāndel fd. force to capture of Dwārka, Dec. 1859; on trgn. Cutch and Kāthiāwār till May 1860; to Murree for recess, returning Kāthiāwār in Oct. [3, 380, 399, 518].

1-2-61, 1st Asst. GTS.; with Bo. party, Kāthiāwār, Gujarāt, Deccan, Kanara, with periods of furl. till appd. DSG. Trig., March 1884 [54-6, 61, 102, 539 n.1].

May 1863, received message from AGG. Indore; "Your brother, Lieut. Haig of the 90th Foot[6] has met with an adventure...in progress to Poona. ... His cart was attacked by a band of robbers about midnight on the 18th inst., some 30 miles to the north of Indore, and though unarmed he jumped out and attacked them, disarming one of them of a sword, and being badly wounded while doing so.

"He was then surrounded by them, and after a further struggle during which he was severely cut in the left arm, one of the bones being cut through, was obliged to run. ... They followed and discovered him, and he again went at them, but was severely wounded in the right arm, and was, of course quite disabled. Fortunately at this moment the road police came up and the robbers ran off. ...

"On hearing of the occurrence...I sent the Residency surgeon off at once to meet him, and he brought him in on the night of the 19th. He is now here and his wounds are getting on very well, ... but he will not of course be able to continue his journey for some time".

Passing this note to the SG. with an appn. for leave of absence, Haig explained that "my brother was travelling from Meerut for...paying me a visit. ... I hope...he may be able to accompany me on my return to Poona. ... The journey in the best open weather is by no means a pleasant one, the only mode of travel being the mail cart from Indore to Munmer [Manmad], a distance of 235 miles, or stage-marching to Jalgaon, a distance of 175 miles'".

18-8-68, obsd. solar eclipse at Bijāpur.

Resd. post of DSG. Trig. at age of 55, 12-10-89, after 30 years in Dept., 25 with Bo. Party.

HAIG, Malcolm Robert. Bo. Inf. & SC.
b. 17-3-30. d. 14-11-1916.
Ens. 13-6-46 ... Maj. 13-6-66 ... ret. as M. Gen. 10-2-16.

Son of Robert Haig and his wife Magdelene, dau. of David Murray of Musselburgh, nr. Edinburgh; 1st cous. to Chas. [*sup*].

m., 27-8-67, Magdelene, dau. of J. W. Straton, of Dundalk; she d., 11-4-1925, aged 84.

2-11-52, appd. asst. rev. survr., Deccan; 1870-1, so. Sind, right bank Indus B [398, 401].

HALPIN, John. Mad. Inf.
bapt., Wicklow, Ireland, 3-7-05.
d., Berhampur, Ganjam, 30-11-48.
Ens. 8-1-28 ... Capt. 1-8-41.

Son of Capt. Wm. Halpin, of King's German Legion [1: 99], and his wife Elizabeth.

BA., Trin. Coll. Dublin, 1826.

MMO. 18-10-42, appd. ASG. in ch. Ganjam topo. svy., with no previous svy. experience; assumed ch. 15-8-43; suffered much from fever [4, 167, 385].

1847, to NW. Him. ser. for special training [35];

Handed over to Howard at Berhampore, 1-10 47, and wrote to Du Vernet from Calcutta on 16th; "I purpose proceeding up the river to Allahabad by the first steamer, thence to Meerut where I hope to be able to procure a tent, horse, and entertain such followers as may be necessary. As you may not be at Mussoorie when I arrive, will you be so good as to write to me at either Allahabad or Meerut, directing me where to join you and by what route[8].

Accd. Du Vernet on trgn. till close of 1847-8 season[9]. Returning to Ganjam was too ill to take the fd. in Oct., and d. the following month [167, 363, 400, 421, 462].

HAMILTON, George. Ben. Inf. & SC.
b., Dinapore, 1824. d., Agra, 29-10-73.
Ens. 9-12-43 ... to SC., Feb. 1861 ... Lt.-Col. 9-12-69.

Son of Capt. J. J. Hamilton (1792-1831), Ben. Inf. Hodson, II (373-4), and his wife Mary Faithfull.

m., Abu, 22-6-59, Alice, b. Nasirābād, 14-5-38, dau. of Capt. D. T. Pollock (1808-43), Ben. Inf., Hodson, III (547-8), *Punjal Inscr.* (147).

arrd. India, May 1844; 1846-9, 1st and 2nd. Sikh wars; siege of Multān.

15-12-51, appd. asst. rev. survr., Rhtkd. under Vanrenen joining 27-1-52; 15-10-55, ch. dott. Gorakhpur; 1-1-56, to ch. Bharatpur [261, 263, 266, 364, 400, 483]; won SG.'s praise [266].

18-2-58, offg. asst. AGG., Rājputāna; July 1859, resd. from svy. on permt. appt. as Asst. to AGG.

Furl. Dec. 1864; Cant. Mgte. Bareilly, April 1867; Bkmr. Chakrāta, 1-6-69, till death.

[1] Lang (20 n.27); frequently referred to as "Ski". [2] being attd. Asstt. Engr., Sandes, I (331 n.2, 332). [3] SG. Records; March 1867 (176-7), from F. C. Anderson, 7-3-67. [4] *GR. Rev. 1866-7*, Gastrell, 5-12-67. [5] not 1835 as in *Burke's LG.* [6] James Felix Haig (1838-1905); Ens. HM. 90th Ft. 1856. [7] DDn. 182 (170-3), 28-5-63, Indore. [8] DDn. 524 (146, 151). [9] *GTS.* IV & *Syn.*, VII (iv—C).

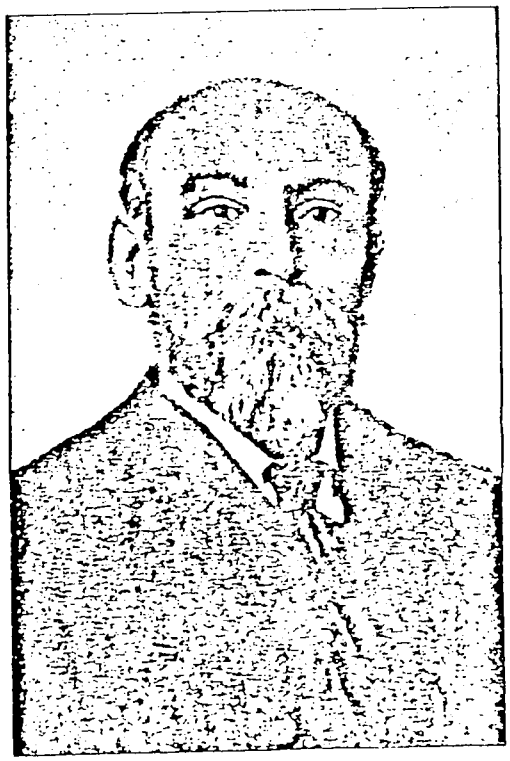
HENRY LANDOR THUILLIER
(1813–1906) F.R.S.
Bengal Artillery
Revenue Surveys 1837–61
Surveyor General 1861–77



GEORGE CHARLES DEPREE
1832–87
Bengal Artillery
Topographical Surveys 1854–83
Surveyor General 1884–87



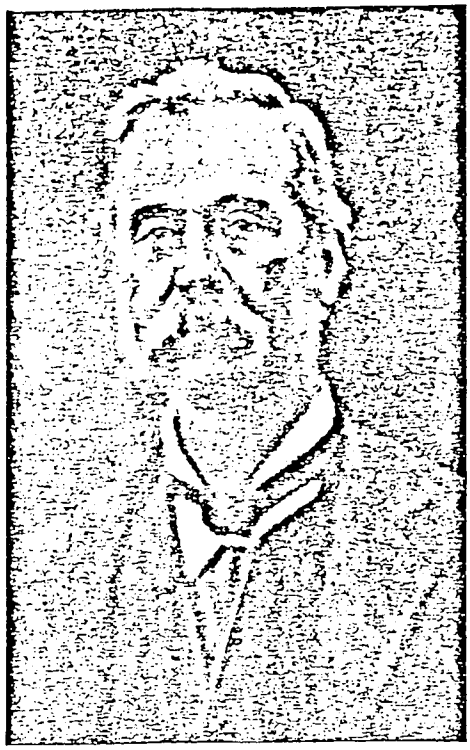
JOHN OWEN NIX JAMES
(born 1829)
Trig. & Topo. Surveys 1845–58
Chief Draughtsman 1858–70
A.S.G. Mapping 1871–83



DANIEL GEORGE ROBINSON
(1826–77)
Bengal Engineers
Topographical Surveys 1850–65
Offg. S.T.S. 1863–5



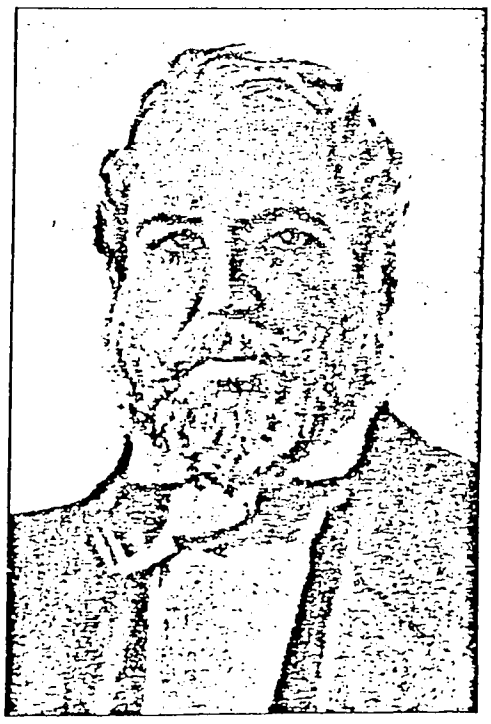
...DONAU NICKTERLIEN
HENNESSEY F.R.S.
(1829–1910)
G.T.S. 1844–84
Supt. Trigonometrical Survey 1884



JOHN HERSCHEL
(1837–1921) F.R.S.
Bengal Engineers
G.T.S. 1853–86



JAMES JEREMIAH PEMBERTON
(1801/2–1860)
Revenue Surveyor
Lower Provinces, Bengal



BRYDGES ROBINSON BRANFILL
(1833–1905)
Bengal Cavalry
G.T.S. 1858–84



HENNESSEY, John Babonau Nichterlein[1].
Civ. Asst. Survr. GTS., uncov.
b., Fatehgarh, 1-8-29; bapt. 21-3-30.
d., Dulwich, London, 23-5-1910.

Sub-Asst. Survr., 14-4-44 ... 2nd Asst. GTS., 25-4-54; 1st Asst., 4-9-58; offg. STS. 1-11-76 to 13-1-77; offg. DSG. Trig. 12-2-83, till cnfmd. Jan. 1884 [503]; ret. 1-10-84.

Son of Michael Henry Hennessey and Mary Lawrence his wife, an Indian[2]. Michael was Acct. in Army Clothing Dept. at Fatehgarh owning No. 2 bungalow and occupying it till his death, 15-9-44; spelt name Hennessy.

The son was named after two local resdts.;

Henry Babonau (1765-1834), Asst. Commy. of Ordnance from 1810; Dep. Commy. 1823, "local" corn. 2nd. Rampura Cav. [III, 489 n.1]; d., Calcutta; MI. Bhowānipore cem[3].

John Nichterlein, German merch. importing borax from Nepāl; left Fatehgarh before 1857 for indigo factory at Mundrah, Aligarh Dist.; d. 10-1-65. Possibly kin to F. Nichterlein, indigo planter, whose son, b. 1866, was at Stokes' sch., Mussoorie, 18-4-81 to Nov. 1884.

DNB. 2nd Suppl. (246-7); *Fatehgarh Camp* (162-3; 193-4); *Notes & Queries*, CLXIV (298); CLXVI (80); *SI. Chasd. List*, 1881; *SI. Services*, 1884; *RAS.* (*mn*), LXXI, 1910 (258-61); *RS. Progs.* 1910; *Times*, 25 & 26-5-1910; *Who Was Who*; *Al. Cantab.*; portrait pl. 25.

Fell. Com., Jesus Coll., 31-10-63; Hon. Mention", Int. Geo. Conf. Paris, 1875; Hon. MA., Camb., 1876; FRS. 1875; FRAS., 1863; FRGS., 1860; CIE., 1885; Athenaeum Club.

m., Calcutta, 31-3-68, Eliza (Elizabeth Golden), dau. of Richd. Malcolm Ashman; their son, *John Arthur Campbell*, of 45th Rattray's Sikhs, was kd in action at Jandola, Waziristān, 23-10-1900; a dau. Mary Mabel, m., Dehra Dūn, 14-1-91, Lt Col. John Anderson, CIE., IMS., and was well known on Mussoorie lawn-tennis courts.

Aug. 1841 to Feb. 1844, emp. at Clothing Agency, Fatehgarh. 14-4-44, appd. sub-asst. GTS., on Armstrong's recdn.[4], SG. writing to Shortrede that he had heard "from Mr. Armstrong...that his relative, Mr. Hennessey, is at present at Futtygurh, and may require a little time to prepare for his examination. As he is just at the age of 15 years, most suitable for acquiring knowledge, ... and being of a reputable family, he may be considered a very desirable candidate. ... I *should*...allow him ample time for qualifying himself for his examination[5]" [416-7, 419].

Shortrede reported on 14th April that Hennessey "joined my camp...on the 13th ultimo, and next day commenced his examination, but two or three days thereafter having fallen sick was obliged to go into Allahābād[6]. He rejoined my camp here on the 1st instant, and renewed his examination. ... I enclose...the solutions given by him [11 n.3]. ...

"His knowledge of algebra appears to be good as far as simple equations. ... He can use Tables of Logarithms, though his acquaintance with them is only very recent. ... He does not, however, require much help, nor to be often told the same thing. Of the principles of trigonometry he as yet knows little or nothing. ... He seems to be a quiet, well-disposed, lad, and I shall feel very glad to have him instead of the Babu [Ram Dial De, IV, 385; V, 418]".

Doubtless Hennessey's talent for maths. was stimulated by service under so eminent a mathematician as Shortrede, but after his first season, 1844-5, he was tr. to Chendwar ser. under Logan, Waugh's most trusted triangulator, who in due course recdd. him for promotion to 2nd class;

"Is thoroughly acquainted with observatory forms, and is an excellent assistant in the observatory [116-7].

"Is remarkably active in the field.

"Is a good and correct computer.

"Is not a very good draftsman, but...promises well.

"Always lives within his income, and keeps a respectable establishment of servants and camp equipage"[8].

Emp. four years under Logan, three of them on NE. Longl. series in the *tarai*, where he suffered constantly from fever; came under SG.'s personal notice at Sonakhoda base-line [17 n.1, 20 n.4]. Assisted in Logan's obsns. of snow peaks, and actually saw the peak later called Pk. XV, or Mount Everest [84, 90, 95].

In 1849, after Radhanath Sickdhar's tr. to Calcutta, Hennessey was tr. to SG.'s hdqrs. at Dehra, but granted sick leave from 20-10-49, that was extended to April 1850. Logan *reported him to be* "a very superior young man, and will, on the perfect restoration of his health, prove...one of the ablest sub-assistants in the Department. ... His present indisposition will for a time unfit him for very arduous employment"[9]. He was himself most depressed about his continued ill-health, and asked for tr. to ch. of a rev. svy., that might give him an easier life, which Waugh refused;

"When I recollect the extreme state of debility you were... reduced to 5 months ago, and...that you are now absent on prolonged sick certificate, ... I cannot imagine that you are physically fit for such an appointment. ... Such an undertaking would only injure your prospects, and perhaps irretrievably destroy your health. ...

"No man can possess an intuitive knowledge of such duties. ... The mere mechanical operations of measuring boundaries and calculating areas anyone could learn in a few days, but this comprises but a small portion of the duties. Forms have to be learned, and the management and arrangement of the business—the method of controlling and checking the native surveyors and ameens—the mode of settling the boundaries—the technical terms—besides many other matters of economy and system, which can easily be learned, but can only be acquired by experience [293-303, 391]. ...

"No man who has never surveyed even a square mile in detail, nor drawn any highly finished map, would have a chance of success"[10].

Sept. 1850, re-tr. to Logan's party when it moved up to the Punjab, and emp. on minor trgn. along the Rāvi and across to the Beās [37]. His fever returned, and he begged to resign; he could not stand the Punjab climate. The SG. offered to tr. him to a party still working in Bengal, but the fever passed and the appn. was withdrawn[11] [410].

He was now brought in to Dehra to assist Renny-Tailyour with comps. and other hdqrs. work and, once again, 8-9-53, asked leave to resign. Govt. sanction was issued on 3rd. Oct., but ten days later he withdrew the appn. and from this time became *reconciled to Deptl. service*. Indeed his services had now become indispensible, and Waugh recdd. his advancement to gazetted rank as 2nd. Asst. GTS. This was authorized under BMC. of 31-5-54, and his pay further increased to Rs. 400 p.m. under BMC., 29-11-55 [78, 388, 403, 416-7].

Served on meast. Chach base-line [43 n.2] and then emp. from 1854 at Dehra on comps. of Hurilaong and NE. Longl. ser. and of the snow peaks.

[1] Bullock's spelling in *Notes & Queries* preferred to Nickterlien (of pl. 25 & *DNB*). [2] Michael m., pr. Calcutta, 27-11-21, Miss Mary Lawrence, elsewhere "Mary bibi". [3] Hodson, IV (559). [4] BMC. 10-4-44; DDn. 451 (99). [5] DDn. 491 (5), 25-1-44. [6] where he had relatives. [7] DDn. 521 (59), 14-4-44. [8] DDn. 496 (178), Logan to SG., 9-4-47. [9] DDn. 503 (32-3), 2-10-49. [10] DDn. 493 (282), 21-3-50. [11] DDn. 612 (6-7); 499 (405), 3 to 25-2-51.

When Brian Hodgson challenged the identity of Pk. XV, and the name Mount Everest, Hennessey was appd. member of the Deptl. Committee to investigate the problem [95]. He was emphatic that "Mr. Hodgson has advanced no evidence whatever to prove" his claim. He pointed out that Peak XV could not possibly be seen " from the confines of Nepāl proper" because of the intervention of Peak XVIII, and yet Hodgson had asserted that his Devadhunga is seen from the *confines* of the valley, and that *it is a great mass*. That gentleman has therefore demonstrated...that Mont Everest[1] and Deva Dhunga are *not* identical. I have seen Mont Everest, certainly from near Titalia in Purnea, very probably from other districts along the terai. It never struck me as a great mass"[2] [95].

It was indeed to Hennessey that Waugh acnowledge his debt for the snow peak comps. [91–3].

In 1858, he was promoted 1st Asst. on full salary Rs. 618 and shortly before leaving India Waugh strongly urged a further increase; for he was "a gentleman of great mathematical abilities, whose...energy and indefatigable industry are only equalled by his theoretical knowledge and practical skill. ... His remaining in the Department on his present salary is...a sacrifice[3]" [128, 136, 342–4, 388].

The inadequacy of his salary, *in comparison* with that of the mil. officers who drew mil. allces. that were periodically increasing with promotion in rank, was emphasized by Walker; "Waugh had said that Hennessey suffers only *because* he is an uncovenanted officer, an obsolete anomaly, which is in some measure a stigma and reproach to us. He urges that a scientific department should recognise no distinction but merit, and should offer to all a fair field without regard to class distinction [380, 390, 407]. " In these opinions I most cordially concur, and I trust that at no distant date invidious differences may be abolished in the Survey Department, as they have been in that of the Public Works".

From 9–12–63, after ref. to SSI., his pay was increased to Rs. 868 pm. [340, 407][4].

24–3–63, sailed from Calcutta on sick leave;

"When I gained sufficient strength [he writes]...I accompanied Sir Andrew Waugh on a visit to the office of the Ordnance Survey at Southampton. ... Being in mind of the wishes of Major Walker, ... I obtained permission...to study the process of photo-zincography, and to visit the field parties of the Ordnance Survey. Leaving London on 8th July I took up my abode at S'Hampton and went through the *entire process*".

He visited field work at Rochester, Edinburgh, and " one of the best hill sketchers in the department, working somewhere in the vicinity of Stronowaihar. I...found Mr. Larkins on the road between that place and Inverslade[5] inking in his previous day's work, seated by a small window in a hut owned by one Duncan Carrochs. The day following I accompanied Larkins over the moors, and saw him sketch in the hills between Lochs Chon and Ard[6]".

He then went to Glasgow, but was unable to visit Dublin. "Nothing can be further from our intention to draw any comparison between the Ordnance and Indian surveys in respect to absolute excellency. Each is the result of long experience combined with considerable skill".

Reported fully on photo-zincography, which he described as " originated by Sir Henry James. He also commented on —printing paper—instruments—store depots—sale of maps—library—spirit levelling—revenue surveys—topographical survey ?" [507].

Entered Jesus College Cambridge as Fellow Commoner [31–10–63], and took course of maths. under William Walton, Rev. Percival Frost, Rev. J. Challis, and J. C. Adams. "He has acquired the habit of independent thinking"[8].

After 6 mo. extension of leave returned to Dehra, to resume ch. of hdqr. offices 4–5–65, these comprising "calculating branch, with small auxiliary branches for drawing, printing, and photo-zincography, instrument depot, etc.". Erected new photo-zinco apparatus, and trained several officers in its use [9, 123, 141, 331, 513 520].

1866–7, corr. with Sabine, PRS. *re* scientific work to be carried out at Dehra. "I am *resident* at Mussoorie from May to October. During the remaining portion of the year I reside at Dehra. In fact the standing office is...at Dehra, and even while resident at Mussoorie, I visit Dehra once a week [497]. ... Monday to Friday my duties claim my attention from 9 a.m. to 4 p.m. ... Saturdays and Sundays my time is entirely my own throughout the year, and though hitherto I have found it necessary to devote all my days to my professional duties, this will no longer be necessary now that I have...the working of my division under systematic control [148 n.3, 157 n.4, 159 n.7, 293 n.3]. ...

"In point of mathematical reading...I devoted my leave of two years to reading at Cambridge, and I hold certificates from Professors of that University in the absence of the ...degree, for which I could not 'reside' sufficiently long"[9].

Took large share with Herschel [504], in compa. for final reduction and adjustment of prcpl. trgn. of GTS., under direction of James Walker, under whom he worked from 1861 [129, 491 n.2].

In 1868–9, held ch. meast. Bangalore base-line; Dec. 1871, with Tennant on obsn. solar eclipse in Nilgiri Hills ; 1874, obsd. transit of Venus [380, 535][10]. 1875–6, furl. on mc., Montgomerie writing from England 1–4–75 ;

"I have seen Hennessey two or three times. He is still looking a good deal pulled down, and I suppose he is wise to take furlough. ... Three months leave is a risky thing for the double journey, especially with wife and child. He tells me ...he is feeling better, and I hope he will soon pick up. He has, I think, made a hit as to the atmosphere round Venus": Clements Markham also writes ; "I saw Hennessey who has an excellent prospect of getting into the Royal Society this year"[11]

Amongst his Cambridge friends of 1863–5 who now greeted him was Isaac Todhunter (1820–84), whose mathl. primers were familiar to many of us in early days [516].

Held actg. ch. of trig. br. during Walker's occasional absence, being confmd. as DSG. Trig. for his last 9 mo.

After rett. in 1884, Hennessey lived for a time in Mussoorie *where since* 1855 he had owned a house, St. Helens[12], and where he had been a member of the Municipality and Capt. of Volunteers. He then migrated to England and settled in Allevn Park, w. Dulwich. Miss Cole, dau. of Wm. Hammond Cole, who had succ. him in ch. of the Comp. Office.

[1] Waugh's early form for the name. [2] DDn. 654 (5), Comm. Progs., para 74. [3] DDn. 654 (5), SG. to Mil. Dept. 6–10–60 (para 74). [4] DDn. 7 (71), STS. to SG., 13–6–61 ; also DDn. 101 (164), STS. to Home Dept. recdg. adjustment of salaries. [5] Inversnaid ? N. end of Loch Lomond. [6] S. of Loch Katrine. [7] Report dated 23–10–63 from JBNH., Oriental Club with DDn. 91 (6); from SSI. to OG. in C., London 24–11–63. [8] DDn. 91 (145); from Wm. Walton, 14–12–64. [9] Eur. Letters I (42), from JBNH. 13–2–66; *RS. Progs.*, 20–6–67. [10] *GR Trig. 1871–2* (appx. 62a, 66) & 1873–4 (67–8). [11] Eur. Letters II (164, 164 A) to JTW. [12] bought by Mahārājah of Kapurthala, 1895; Stokes Sch. Regr. (109).

relates his visiting them at Croydon about 1897. He had just visited his son at Sandhurst, and besides tipping him half-a-crown had given another half-crown to a son of the King of Siam, a fellow cadet he had been introduced to.

Hennessey's amazing rise from a fifteen-year old sub-asst. of very ordinary origin to be head of the trigonometrical branch, and his FRS., was due to his remarkable flair for mathematics, his scrupulous regard to minute precision, and to his natural genius for the practical application of theory to the problems of geodetic survey and astronomy. His career was for very many years a gleaming beacon to survey officers of the uncovenanted service.

HERSCHEL, John. Ben. Engrs.
b., Capetown, 29-10-37. d. 31-5-1921.

2/Lt. 12-12-56 ... Lt.-Col. 10-3-83; ret. as Col. 10-3-86.

Son of famous astr. John Fredk. Wm. Herschel (1792-1871), 1st Bart., himself son of equally famous Wm. Herschel (1736-1822), from Hanover; both *DNB.* and FRS., and with memorials Westminster Abbey[1]; His mother was Margaret Brodie, dau. of Rev. Alex. Stewart, DD.

ed. Clapham Gr. Sch., and Addiscombe 1855-6, winning Pollock Medal.

m., 1867, Mary Cornwallis, dau. of Rev. F. Lipscomb, rector of Welbury, Yorks., and wid. of David Power, QC.; she d., Mussoorie, 10-10-76, aged 47.

RAS. (*mn*), LXXXII, 1922 (250), with portrait in groups I and II; also from photo. [pl. 25]. *SI. List, Services*, 1884; *SI. Notes*, 1-5-86; *GR. 1885-6*; Conolly (93/323).

FRS., 1871; FRAS.; 1872, Council, 1884; Member of Senate, Cal. Univ.

arrd. India 2-1-59; 2nd. Asst. GTS., 3-11-59; 1st Asst., 1-2-61 [380-1, 399].

He spent his first two seasons on the Gt. Indus ser., and in 1861-2 held ch. Sutlej ser. [49, 53]; introduced new pattern referring lamp, *GR Trig. 1861-2* (4.n). 1863, on Hennessey's departure on furl., to ch. Comp. and other hdqr. offices at Dehra; started reduction of GTS. trgn., Robinson reporting;

"Lieut. John Herschel, whose scientific acquirements and business habits prove him a worthy inheritor of the honored name he bears, has continued his investigations and matured the mechanical application of formulæ...for the reduction of all geodetical figures on the principle of minimum squares. ...

"The rigorous simultaneous reduction of any kind of figure is effected by purely mechanical processes in a far shorter period, and with less labour, than was formerly the case"[2].

Herschel introduced various methods of calculation specially suited to the compg. staff [129, 502].

His father wrote on Walker's departure from England; 8-12-64; "Lady Herschel deputes me to reply to your note announcing your proposed return to India, and your obliging offer to convey a parcel to our son, which his sister Maria will take advantage of, and will take care that her drawings... shall reach you before the 15th. ... They are not large and will all lay flat at the bottom of any portmanteau.

"I am much gratified John's having completed to your satisfaction a heavy burden of calculations. I never get a letter from him without expressions of his liking for—indeed fondness of—the work he is engaged in".

[and again two days later] "I get by an odd coincidence from Airy this morning a paper on the reduction applicable to the Indian Survey. Of course you have it. I shall send my copy to John. ... My daughter Maria bids me say...that on Monday next, 12th, you shall have her present for John, a flat packet of drawings on cardboard. She hopes...it will not be inconvenient of carriage[3].

April 1866 to Dec. 1867, sick leave to England; Nov. 1868, obsns. of nebula of *Eta Argus* at Bangalore; emp. till 1879 with parties in fd., or with comp. party at Dehra, with 2 y. furl. from Aug. 1873. Work covered prcpl. trgn.—meast. of base-line at Bangalore and Cape Comorin—obsns. of astr. lats. with Strange's zenith sector—obsns. for telegraphic longs.—eclipses of Sun, 18-8-68 and 12-12-71—redcn. of Basevi's pendulum obsns. [533].

From Nov. 1879 on special duty in England; pendulum obsns. at Kew, Greenwich, and Washington, till ret. 10-3-86.

Auth. of many scientific papers; *Roorkee Papers*, I, 1863-4 (308-16), *Local Attraction*; *Phil. Trans.* 205 (399), *Gravity*, etc.; Biog. note on his g. father, Sir Wm.

Whilst on furl. 1873-5, writes to Walker from Collingwood, 20-11-74, telling of visit proposed to Biarritz, "where we are going to take refuge. ... The necessity of avoiding the English winter has become a still more obvious duty. ... My wife has been suffering almost uninterruptedly for the last six months from asthma, ... and unless a southern climate proves alleviating, there is very little prospect of any comfort for her in this life. ... Our stay abroad will practically swallow up nearly all that is left of my furlough, as we shall probably not return till May or June. ...

"I am frequently asked...what part of India I have been in. It is not very difficult to answer 'Well, in most parts', but when the question is to what part am I going to return, I can only reply 'I have no idea'. ... I hope you will be able in the course of the next few months to let me have some means of estimating this. ...

"After leaving London in July I went with my wife in search of health and change to Scotland and Ireland, and round by Devonshire and south coast to Hastings, stopping one day at Brighton"[4].

Mrs. Herschel d. at Mussoorie shortly after their return to duty.

HESSEY, William Henry. Mad. Inf. & SC.
b. 11-7-28. d., 14-2-99.

Ens. 20-8-45 ... SC. 18-2-61 ... Bt. Col. 20-8-76; ret. as Hon. M. Gen. 16-12-77.

Son of J. A. Hessey, bookseller, Fleet St., and his wife Catherine.

Mad. Services; Markham [190, 193].

Arrd. India 30-9-45.

3-11-54, appd. asst. rev. survr. under Priestley, S. Arcot; 19-3-58, appd. Dep. Supt.; held various charges Trichi., Wynād, Salem, Coimbatore; sick leave to Eur. 1862-3 & 1873; [280]. No. I Party, Coimbatore & Salem; 1869, conducting "a very elaborate survey of a revenue and topographical character of Ootacamund and Coonoor, on a large scale, ... but not connected with any triangulation. Branfill to provide points"[5] [401].

actg. Supt. during Priestley's occasional absence between 1863 and '76; cnfmd. Supt. 6-7-76; furl. from 16-1-77.

HILL, Charles Thorold [III, 458; IV, 447]. Mad. Inf.
b. 19-2-09. d., London, 18-11-57.

Ens. 8-1-26 ... Maj. 3-8-55; ret. as Lt. Col. 23-7-56.

Son of Capt. Henry Hill, RN., and Caroline, dau. of Joseph Bettesworth, of IW., his 2nd. wife.

m., in England, 29-8-44, Emma Harriet, dau. of Geo. Edw. Russell, MCS., Comnr., Ganjam [IV, 253]; she d., Shanghai, 7-10-50.

[1] *Times*, 12-8-1955. [2] *GR Trig., 1862-3* (13); JTW., 1-9-63; *1863-4* (11). DGR., 1-11-64. [3] Eur. Letters, I (32-3). [4] ib. II (99). [5] DDn. 395, SG. to GTS., 21-9-69.

Oriental Club.

1829–34, asst. in Madras topo. svys., Ganjam & Nellore; 1834–41, in ch. svys. Trichinopoly, Goomsur, Ganjam [IV, 253–5, 447]; furl. on mc., Oct. 1841 to Feb. 1845 [4, 167].

20–6–44, applies to Directors for permission to return to India, and to be emp. conng. his Ganjam trgn. to GTS.; supported by Directors, and appd. to GTS., GO GG. in C. 31–1–45, joining SG. at Allahābād, March 1845[1] [379].

DO. 2–8–45, appd. to ch. of Karara party from 1–9–45, to "conduct a survey along the Coast from Calcutta towards Ganjam...taking the field on or about 1st October...according to the state of the weather [12, 184, 346, 361]".

From March to Oct. engaged at Allahābād "arranging his Gumsur surveys and in aquiring knowledge of the Great Trigonometrical Survey". From Nov. 1845 to Feb. 1847 carried Maluncha ser. south from Asansol towards Midnapore. 1848, ran levels from Kidderpore to base-line towers [21, 71]. Then started Coast Ser. from the Barrackpore base-line across Calcutta to the south, through very difficult congested country. [22–6, 29, 98, 108–9, 149, 152, 169, 385, 413, 415]. He writes to SG. 5–1–49;

"When I last wrote to you I mentioned I was going out for some shooting previous to taking the field. .... A ride of 16 miles one afternoon, and two successive days in the howdah from daylight till dark, knocked me up, and kept me on my bed for a week, ... nor am I yet fairly well again. ... The fact was I overworked myself before I fairly recovered from my last attack [457].

"Mrs. Hill and the babas are safely lodged at Serampore with her brother[2]. We have no roads here. Those marked as dak roads in the map are merely narrow footpaths along the top of the embankments, ... but in spite of all difficulties, ... I am quite satisfied that we did right in choosing this line...for the principal triangulation. The direct line from the base to the hills near Balasore would have given me trouble, ... and the expense would have been far greater from the immense quantity of fruit trees surrounding the very thickly clustered villages [468, 477–8].

"The country is beginning to dry a little, and I leave this in a day or two to follow the line of coast all the way to Balasore if possible. ... I shall during this trip be able to select a spot for observing the rise of the tide. ... What I wish to do is to take the stars in April, observe the tide, and make the experimental observations all at the same station...near the Coircoliy lighthouse [15, 21, 26, 71]. ...

"I must, if possible, avoid a high tower at the place where ...there will be a furious sw. wind blowing on the coast. ... The large theodolite will be required to be in position for two to three weeks at least. ...

"There are some tigers reported close to my camp, but I have not had time to look after them yet. Buffaloes and deer abound further down the coast, I believe. I have a heavy battery ready for them [467, *sup.*].

"This letter has been spun out over a great deal of paper; I hope you won't vote me a great bore. ...

"PS. When will you and I smoke cigars till 2 o'clock in the morning again? When we reach the Madras race-course (base-line) shall we do it?"

He writes from Midnapore seven months later; "Society here has all altered since we were last here. New Judge, Collector, and Magistrate, and the Madras regiment had arrived only a few days before we left this last season. So I find myself the oldest inhabitant.

"Can you give me any hints about an ice-house? I built one here last year which met the approval of the Calcutta savants, as well as the more practical Yankee, Mr. S. The ice remained till about the middle of May, when it suddenly melted away and disappeared in a few days. Could you give me a rough sketch of an ice-pit such as is used in the North-West? [366]. "Ever yours, my dear Waugh, very sincerely", C. Thorold Hill[4].

April 1850, took two years leave on mc., with his family, for sea voyage planned for New South Wales but lost his wife who died at Shanghai in Oct.; resumed ch. of Coast ser. at Midnapore, 11–5–51, but still in wretched health, writing to SG., 6–6–51;

"I am getting better again, but am much reduced, and very weak. Unless some decided improvement takes place I shall apply for leave from 1st August, ... and if possible go by the September steamer to Madras, and so on to the hills. — Of course, I am very loth to do this, but it is no use trifling. If I was fated not to recover, I shall have no recourse but to go to Europe. I had no fair play on my last trip, but notwithstanding benefitted to a certain extent. ...

"In my present state of health, though able to attend to office duties, I am not fit to take the field. ... I only wish I had wisely gone away a year or two sooner. ... The spirit is willing, but the flesh is weak, and it is lamentable that one so strong as I have been in my day should be thus brought low. Oh that I were only quite myself again" [382].

"PS. If your snowy ranges [were] more accessible, I should like to see them, and in that climate I should soon recover, but I fear the long journey by land at this season"[5].

Granted 12 mo. leave on mc. from July 1851, spending this at Ootacamund in the Nilgiri Hills, and under GO. of 20–10–52, granted extension for another year, at the expiry of which he reported at Calcutta 5–7–53. As his general state of health was far too poor to allow any prospect of active duty in the field, he was allowed to resign, and sailed from Calcutta about 19th Dec. 1853 [399, 462][6].

HUTCHINSON, William Caldwell. Ben. Art.

b., Burdwān, 12–5–24.

d., Simla, 3–9–48; MI., cart rd. cem.

2/Lt. 11–6–41; Lieut. 29–12–43.

Son of John Ross Hutchinson, BCS. and Caroline Jemima, dau. of Col. Wm. Caldwell, HM. 77th Ft.

ed. Rugby 1837–40; Addiscombe, 1840–1.

1842–3, mil. service Bundelkhand; 1845–6, 1st Sikh War.

FD. 30–7–46, appd. Asst. Survr. trans-Sutlej svy. under Becher; succ. to ch. Oct., 1847 till death following year [270, 396, 400, 492].

JAMES, Henry Currey[7]. Ben. Inf.

bapt. 25–5–17. d., Rome, 13–4–66.

Ens. 12–6–35 .. Lt.-Col. 18–2–63.

Son of Thos. James, surg., of Croydon, and Rebecca his wife.

ed. Addiscombe; "grounded in rudiments of survey".

2–4–42, applies for appt. to rev. svy., Bihār.

BRC. 17–3–48, appd. asst. rev. survr,; attd. to No. 2 Div., 24-Parganas; 1–10–48, tr. to No. 4 Div., Bhāgalpur, but under GO. GG. joined regt. at Ferozepore, remaining there with Army of the Punjab, till 20–3–49; rejoined No. 4 Div. rev. svy., at Bhāgalpur 28–11–49 [400][8].

6–2–50, applies for leave preparatory to furl., Sherwill writing, 5–3–50; "James, who has been ill with dysentery, starts tomorrow by dak to Calcutta. He is in very bad health and requires an English climate to restore him.

[1] DDn. 506 (68), 31–1–45. [2] Richd. Henry Russell (1821–63); BCS. [3] DDn. 507 (50), camp Natsol, 5–1–49. [4] Ib. (55), 24–8–49. [5] Ib. (152), 6–6–51. [6] DDn. 551 (146), BMC., 29–11–53. [7] Curry in early lists. [8] DLR. 37/63 (104, 122, 258).

"Should an assistant be appointed to my survey, I hope it will be a younger man than James, one that I could teach and *make* work. James is too near me in age and, being equal in rank, I found it difficult to order him to work. He is willing enough, and a very nice, gentlemanly fellow[1]".

Sailed from Hooghly R., 10-4-50 and did not rejoin Svy. On return from furl. writes from Calcutta, 6-12-53, that he had spent some time on "the study of chemistry at the Government School of Mines in London". He pointed out the commercial importance of borax from Ladākh[2].

JOHNSON, Charles Cooper. Ben. Inf.
b. 20-12-27. d. 6-12-1905.

Ens. 7-6-44 ... M. Gen. 14-1-86.

Son of Sir Henry Allen Johnson, 2nd Bart., of New York and g. son of Gen. Sir Wm. Johnson (1715-74), from Ireland, *DNB.*; c. Bart. 1755 for mil. victory at Crown Pt. 1755; recd. grants of land N. of Mohawk R., New York Prov., then a British possession. Sir Henry m. Charlotte Elizabeth, dau. of Fredk. Philipse, of Philipseburg, NY.

ed. Addiscombe.

m., Harberton, Devon, 4-1-60, Jemima Anne Frances, dau. of Rev. Geo. Martin of Exeter.

ROB., 1881; GCB., 1900; JP. Worcester; *Who Was Who.*

1st Sikh War, battle of Sobraon, 10-2-46.

BMC., 28-2-56, appd. asst. Kashmir topo. svy.; 31-3-56, as DAQMG., reports start from Ambāla 30th March *en route* to Kashmir via Bhimbar, reaching Srinagar by end April; after instn. by Montgomerie survd. by planetable some 600 sq. m. nr. Islāmābād, but interrupted by serious illness. Oct., reverted to mil. duty [225, 388, 400, 511].

1857-8, mutiny campaign, Lucknow; 1868, Black Mtn. expn. Hazāra; 1878-80, QMG., Afghān campaign.

JOHNSON, Edward Thomas Smith.
Asst. Rev. Survr., Bengal, uncov.
b., Sewanker, nr. Delhi 28-4-28.
d., Hazāribāgh, 7-1-92.

Junr. sub-asst. 13-10-47 ... 1st. gr. sub-asst. 1-10-53 ... 3rd. gr. Dep. Supt. 5-7-70; ret. 29-4-83.

Son of Condr. Thos. Johnson of Ordn. Dept., b. 11-8-1796; d., DDn., 7-10-78; MI. DDn. cem., bur. alongside Hannah his wife who d. 9-7-52, aged 54 y. 7 mo.; Edw. was bro. to Wm. Henry [*inf*].

ed. Mackinnon's Sch., Mussoorie.

m., Missri. 30-10-54, Octavia Eleanor, dau. of Thos. Steele.

13-10-47, joined Ajmer & Merwāra rev. svy. under Donald Vanrenen [265-6]; 1-11-48, to Delhi & Rohilkhand; 1-10-54, to Jubbulpore; Vanrenen writes in 1851; that he could not speak too highly of him. "Next to Mr. Hoppner he is the best educated uncovenanted assistant with me, and smart both in the field and in office[3]" [260, 433].

16-10-54, lent to Nimach svy. under Dennys; being "the only officer of any experience in this survey [266]"[4]. Rejoined at Jubbulpore 21-1-56.

1-11-61, joined rev. svy. DO. Calcutta after death of Walter Graham [384]. From 1862 to ch. of Darjeeling "waste lands" svy. and, 1863-4, in ch. tea plantations svys., and then of various irrigation and cadastral svys. in NWP. [436, 441].

JOHNSON, William Henry. Civ. Asst. GTS., uncov.
b., Upper India, *c.* 1-4-32.
d., Jammu, 3-2-83[5].

Sub. Asst. GTS. 3rd. cl., 1-9-48 ... sonr. SAS., 1-9-55; civ. 2nd Asst. 1-11-58. 1st. Asst. 1-4-66; resd. 15-10-66.

Bro. of Edw. of rev. svy. [*sup*].

ed. Mackinnon's, or Maddock's, sch. Mussoorie.

m., Landour, 20-6-51, Anne Monk dau. of John Weller; she d., Srinagar, Kashmir, 24-12-1901, aged 67. They had 13 children of whom 4 were at Stokes' Sch., Mussoorie, viz.—

Thos. Geo., b., Mussoorie, 2-9-56; Stokes' Sch. 1867-72; Victoria Coll., Jersey, 1873-7; RMC. Sandhurst, 1877-9; HM. 79th Ft., Ens. 1879; Zulu War; Ben. SC. 1881; 1884 Burma Comn., Sessions Judge; d, ptomaine poison, Henzada, 1901—Edwin Gilbert, b. 1-11-58—Wm. Edm., b. 14-9-61—Arthur Edw., b., DDn. 11-10-62[6].

Their yst. dau. Teresa St. Josephine, b., Mussoorie, 25-2-71, m. 27-10-99 Roland Geo. Allanson, 5th Baron Headley (1855-1935), with timber firm, Kashmir; Presdt. of Brit. Muslim Soc., pilgrim to Mecca 1923; their son becoming 6th Baron 1935; she d. 23-10-1919[7].

Another dau. Ada Esther Julia, b., DDn., 10-11-65, d., Srinagar, 2-1-1943.

Member ASB., 1866; FRGS. 1866; gold watch 1875.

JRGS., XXXVII, 1867 (1-47) with map; *GR Trig., 1865-6* (9-10); *RGS Progs.*, XI, 1867 (4-7, 10), with map; XVI, 1873 (197-263); XIX, 1875 (347); V (ns), 1883 (291-3), ob. by Godwin-Austen; *Pioneer*, Feb. 8 & 27, March 19th, 1883; *GJ.*, XXXII, 1908 (94); *AJ.*, Nov. 1921 (1-15), Mason, *E 61*; Mason (79-80); *Tarikh Jammo*, with portrait, heavily bearded (425-6).

Sept. 1848, joined NW. Him. ser. under Du Vernet [201-2, 422]; 1850-1, survd. with planetable between Simla and Chaur Peak [5, 36 n.4].

1851-4, under Logan on prcpl. trgn. NW. Longl.; 1851-2, constructed station at Murree, asstd. SG. on selection of site Chach base-line and connected Walker's Yusufzai base [215], making large-scale sketch round Attock[8]; on meast. Chach base [43 n.2, 50 n.3].

1854, with Mulheran to Upper Sutlej, making conn. via Baspa R. across great snow range that, writes Mulheran, "has been unsuccessfully attempted by myself and two others, ... some of the stations... being upwards of 18 and 19,000 feet, ... and peculiarly difficult of access from the immense quantities of snow that covered the north features of the great snowy range bounding Bushire [Bashahr]. The peak known as Nela Station, ... situated immediately above the great glacier on the northern face of the Nela Pass, was approached by Mr. Johnson over the Chote Ghatī glacier, the fissures of which were impassable a few days after he had occupied the station [208, 423]"[9].

Took Himālaya topo. party to meet Montgomerie at Amritsar for Kashmir svy., 22-2-55, and took leading part in lay-out of prcpl. trgn. across Pir Panjāl range to Srinagar, covering "no less than 165 miles in 4½ months", and sleeping several nights on the snow-covered peaks. He then took minor trgn. up "the Lidar River, across a snowy range to Ambernath, down the Sind River, and finally closing on the side Zabarwan to Safarpoor", and making "a neat planetable sketch [221-5, 404]"[10].

During the cold weather accd. the party to Dehra Dūn to work on comps. An alarm about his health

[1] DLR 37/57 (21, 29, 41). [2] *Punjab Sel.* II, xii, 1855. [3] DDn. 485 (12), Vanrenen to DSG., 20-1-51. [4] DDn. 624 (144), DSG. to SG., 5-4-56. [5] not March as in *RGS Progs.* V, 1883 (291-3). [6] Stokes' Sch. Regr., 13/90; 24/163; 27-8/184-5. [7] Burke, 1956 (1075). [8] DDn. 610 (88), Logan to SG., 27-7-52. [9] DDn. 51 (110), to SG., 10-8-& 11-11-54. [10] DDn. 51 (109), TGM. to SG., 20-3-56.

early in 1856 was short-lived ; after marching up by the Banihāl route he was emp. on minor trgn. to fix points for planetablers astride Kishanganga R., and on main apprx. ser. N. towards Skardo [225–6, 405][1].

Season 1857, completed gaps in planetabling left by mil. survrs. in SE. area of valley, and from June to Sept. extended approx. ser. to Indus and up the river to a point just short of Drās R. junction, returning to Srinagar 25–9–57 [227].

During 1858 spent early months fixing trig. points for planetablers SE. of Jammu. From July continued main approx. ser. up Indus, and from Sept. started separate ser. up Shyok R. "The Shyok triangulation" wrote Montgomerie, "is a very important one, the river being very little, if at all, inferior to the Indus itself [88–9, 232–5 ; pl. 6].

May 1859, fixing points for planetablers in Bāramūla area, and then continued main ser. into Ladākh, carrying prcpl. obsns. from Skardo upwards, as well as extending recce. E. wards to junction of Zānskār R., obsg. K 2 and other lofty peaks. Closed work in Sept. just below Leh, being halted by early winter. He worked throughout, "writes Montgomerie, "like a thorough mountaineer, and took his toil kindly. The observations and the progress made in a very difficult country, with several stations above 18,000 feet, are highly creditable" [3, 233–4, 425][2].

May 1860, training beginners in Kishanganga area. He then closed prcpl. ser. at Leh, and took up minor ser. to cover planetable needs and to connect with Mulheran's trgn. of 1851 nr. Bārā Lācha La. [202]. " Considering your long experience ", ... writes Montgomerie, "and your acquaintance with all the precautions necessary, ... I have every confidence that you will get on as well in the neighbourhood of the Tartar encampments as you have hitherto in other parts" [234][3].

One station above the Indus was 19,600 ft. above the sea, and a mark was established on peak of 21,483 ft. ; in Rupshu he twice ascended one station of 19,979 ft. [235, 481].

He completed the Rupshu ser. up to Bārā Lācha La during 1861, and it was during this season that some rays to peaks north of Spiti R. became confused, resulting in a few false points being computed as falling south of main range, one of these, with the impossible height for that neighbourhood of 23,050 ft., being later named " the Shilla Peak" . This was no fault of Johnson's, but the comprs. should have rejected all points fixed by two rays only [91, 221, 234 n.5].

During 1862, he ran another ser. of minor triangles east of Leh, this time N. of the Indus, up Changchenmo valley. He had two stations of over 20,000 and climbed one of 21,072, but could not observe from it owing to heavy fall of snow. He fixed a peak of 23,890, E 61, in the Kuen Lun mountains about 100 m. to N. and worked to the accepted limit of the Māharāja's territories [236–7, 417–9].

During 1863 had his first respite for nine years from arduous mountaineering, being emp. on office duties at Dehra, from March with Sutlej ser., and from April to Sept. in ch. of levelling party. Re-posted to Kashmir party 1–10–63 [408].

About this time various changes were made in organization of the Dept., and Johnson declined tr. to the newly separated topo. branch, preferring to remain on trig. side. At the same time he submitted memorial, 21–9–63, regarding his position in the Dept., following this, 4–2–64, with a protest at appt. of Lieut. Carter to ch. of Kashmir svy. over his head. He claimed that as Civ. 2nd Asst. he had equal standing with mil. 2nd Assts. OTS. :

"My supersession...can only be warranted on the score of my incapacity to take charge. ... The late Surveyor General and my senior officers not only have...[recognized] my ability to take charge, but...I have been placed from time to time in temporary charge of the Kashmir Series, when the strength ... "[comprised]" six civ. assts., all his juniors, and three mil. topo. assts., Austen, Melville, and De Brett. "I also have had charge of the G.T. Survey levelling operations for a period of 6 months"[4].

His petition met with no sympathy ; appt. of civ. assts. to executive charge was made to selected individuals after most careful consideration [408–9][5].

During 1864, Johnson returned to Ladākh with Clarke and Low to clear up all blank areas within Māharāja's territories. They survd. a gap near Pangong Lake and sketched Lingzi Tang plains north of Changchenmo. They filled in the rough mountain area drained by the upper Shyok, the Nubra, and the Karakāsh rivers. The country was utterly desolate ; fuel and food had to be carried the whole way, Clarke taking ch. of supply column for Johnson's more extended thrusts. Nothing was carried beyond absolute necessaries of life, and squads were kept to lowest possible number [237].

He worked his way through the terrific gorges and ridges of eastern Karakoram till he reached the Pass, descended three marches to the north, and sketched as much as he could before closing work. Unfortunately none of this work, which touched on the Remo and Siachen glaciers, was of any accuracy. Indeed Henry Wood who survd. this area with the De Filippi expn. of 1914 declared after close exmn. of Johnson's fd. sections that "it is absolutely inconceivable how any trained surveyor...could have produced a map so unlike the ground"[8] [237 n.2].

With final report announcing completion of Kashmir svy. Montgomerie recdd. that Johnson should have special increase of pay, Rs. 100 pm. ; "He has never spared himself, and indeed I think his health has suffered not a little. ... He has been distinguished for his kindly treatment of the natives of the various countries with whom he has come in contact. In Ladak and on the borders of Tartary he has always been able to get men to follow him. ... The Tartars and others have always been willing to rejoin him for a fresh expedition".

"Mr. Johnson has now earned some more substantial reward than mere words, and...if a personal allowance is granted to him. ... a strong incentive will be held out to others to follow his excellent example"[9]. The increment was sanctioned with promotion to 1st cl. Asst. from 1–4–66.

On Montgomerie's strong recdn. Johnson was allowed one more visit to the far NE. borders, to fill in as much as he could of the inaccessible country by distant sketching ; "Captain Austen...thought that the whole of the ground in that direction might be sketched without touching upon any of the country actually occupied by the Chinese Tartars"[10].

[1] DDn. 718 (64–5), TGM. to SG., 26–3–57. [2] DDn. 717 (96), Sept. report, 3–10–59 (182), report for 1958–9 ; *GTS. Syn.*, VII (xxiii—C). [3] DDn. 717 (173), 13–5–60. [4] By trgn. of 1963, 20,050 ft. [5] DDn. 7 (161), 25–9–63. [6] DDn. 5 (108), to STS., 4–2–64. [7] DDn. 93 (256–7, 266 1/2), STS. to Home Dept. 3–1–& 11–2–67 stresses impossibility of placing mil. offrs. under civil assts. [8] Wood, H (28–35 ; FS.) 1922. [9] DDn. 51 (121), TGM. to STS., 20–12–64 (125), 16–1–65, 93 [256–7], 3–1–67. [10] DDn. 61 (125), TGM. to STS., 16–1–65.

So at the end of May 1865 Johnson set out with Low who found more ground to sketch[1]. At Leh Johnson received a call from the Khān of Khotān to visit his capital. Well aware that this would be forbidden territory to a Govt. official, he snatched at his chance. After several weeks exploring the head of the Karakāsh R., and climbing the Kuen Lun range, he met messengers from Khotān who escorted him to Ilchi. "After a wearisome march of 11 days...over a distance of about 150 miles, Johnson reached Ilchi on 17th Sept. Three miles out he was met by the Khan's two sons who, with an escort of 40 horsemen, accompanied him as he passed through the gate of the city".

He was comfortably housed and saw the Khān and his sons nearly every day. He was allowed post-horses to visit Keriya, 40 m. to E., and other places. "The Khān, tho' he offered no objection to my using the planetable, ... opposed my taking astronomical observations. ... His courtiers considered that it might be a preliminary to the country being taken possession of by the British. Succeeded, after taking special precautions to keep off intruders. ...

"After leaving Ilchi I was not able to observe for latitude at any other place save Sanju, where...I put up in a house with a large hole in the roof which admitted of my observing with the 8-inch theodolite, ... locking the door. Boiling point observations for height taken at every halting place"[2].

After 16 days at Ilchi he returned to Leh by way of Sanju, Shahid-ullah, and the Karakoram Pass, climbing several peaks on the way. He reached Leh on 1st Dec. and found 4 ft. of snow on the Drās Pass; he and several of his men got frost-bitten. Reaching Srinagar on 9th Dec. he was back in Dehra on 28th Feb. 1866 [237–8].

The Punjab Govt. had news of Johnson's movements early in Sept. and the Foreign Dept. in Simla promptly wrote to STS. that "No person should ever be allowed to go beyond British territory, and more particularly into wild or dangerous tracts without specific sanction", but, they wrote a month later, "as that gentleman has actually gone to Khotan, ... H.E. in Council will be glad to have a report embodying all the information which Mr. Johnson may have acquired during his visit"[3].

With Walker's help Johnson now made out his report, his comps. and his map were revised. "His report", writes Walker, "had to be entirely re-written in my office. He brought a map which has had to be re-cast, and reductions of astronomical observations which have had to be re-reduced. In their original state all three were unfit for publication.

"He had made an error in projecting one of his initial trigonometrical stations which threw out the whole of his map. His observations...by the pole star were really reliable, but his reduction...was erroneous by half a degree".

[and again later] "I sat him down by my side and extracted out of him the information of real value. ... Part of his final report I wrote myself; remainder was by Hennessey and Duhan. I showed him how to correct his map and made a 1st projection myself to make sure there were no mistakes"[4].

"The map...has been printed by the recently invented process of photo-zincography, and is the first product of the new apparatus procured in England"[5]. A further report, on pol. subjects in Johnson's own hand was dated 22–4–66.

An unfortunate result of the faulty plotting of his fd. section was his mis-identification of the peaks along the Kuen Lun range that he had intersected during 1861–2, and his mistaken claim to have climbed, and observed from, Pk. E 61, 23,890 ft. [236]. This has been discussed by Mason in *AJ.* of Nov. 1921, which includes a note by Sir Aurel Stein discussing the faulty topography that resulted[6].

Montgomerie wrote from England later, 1–4–75; "I see Elchi has shifted nearly half a degree to the East. Hayward...thought Johnson had got it too near Sanjoo". Johnson had got into a coil with his planetable, and though his longitude seems to have been all right, he never sufficiently explained what he had been about"[6].

With his prof. report and map Johnson submitted claim for reward and for cost of gifts made to the Khān and his officials. Govt. was sympathetic; "H.E the GG in C. consider the report to be very interesting and creditable to Mr. Johnson. As Mr. Johnson did go to Khotan it is satisfactory that he was able to collect so much information.

"The whole cost of Mr. Johnson's travels in Khotan, whether on account of presents to the great men of the country, or for any other matter, will be re-imbursed to him, & also the value of the Government telescopes presented to the Ruler...may be written off, ... and the proposed gratuities of 6 months pay to certain of Mr. Johnson's attendants are sanctioned.

"But H.E. in Council cannot...reward Mr. Johnson without special sanction. ... Mr. Johnson ought not to have crossed the further frontier of the Maharajah's...territories, and in fact he has been already censured for having done so. No doubt his conduct was enterprising and public spirited, and the information he has been enabled to gather may prove useful. But...had Mr. Johnson and his party been detained at Khotan, or murdered on the way, he would have involved the Government in all the odium arising out of an unredressed injury to one of its British servants. ... The case of Mr. A. Schlagintweit...shews the great danger." [146, 528][7].

15–10–66, Johnson asked leave to resgn. his svy. appt., being, writes Walker, "disappointed at not receiving reward for expedition to Khotan—his prospects of departmental promotion not sufficiently brilliant—but mainly because he has been offered employment by the Maharajah of Kashmir at treble his present salary". Govt. accepted the resgn[10].

Two months later, Johnson had an interview with GG, Sir John Lawrence to whom he told at Dehra an entirely different story; "He had not proceeded beyond the limit to which he was urged by his superiors to go, when he met a party of mountaineers who compelled him to go on. ... So far from being treated as a free man and with courtesy while in Khotan, he was virtually a prisoner there, and was only allowed to leave the country after distributing considerable sums to the extent of Rs. 15,000 to 16,000 in presents, in addition to those for which he received compensation.

"He had raised this money from the merchants of Khotan who were glad to be able in this way to send money out of the country. ... He had intended repaying the amount himself out of a reward which he had expected from the Government of India".

He was told to submit his claim through the SrS[11].

In forwarding the new claims, and new story, Walker comments that the original instns. had "only permitted *distant* sketching across the border. Instead of carrying out his instructions, he carried out a programme of his own which I have reason to believe he had long been maturing, for when I asked him where he got the Rs. 2,366 which he gave away in...presents, he replied that he had borrowed it for this purpose from a bank in Mussoorie before starting.

[1] *GR. Trig. & Topo. 1864–65* (appx. 8, xliii–iv), Report by Carter. [2] *GTS. Syn.*, VII (xxxix–xli—C); *JRGS.*, XXXVII, 1867 (14). [3] DDn. 91 (364, 413), FD. to STS., 21–10 & 18–11–65. [4] DDn. 93 (256–7), STS. to Home Dept., 3–1–67; (266½), 11–2–67. [5] DDn. 93 (201), STS. to Home Dept., 23–5–66; see map 16 m. to inch, *IO Cat.* (257) with bdy. line; also *JRGS.* 37 & *NF. Atlas*. [6] *GJ.* XXXII, 1908 (94); Mason, *E. 61*; *AJ.* XXXIII (296). [7] J. W. Hayward, 89th & 79th Ft. 1859–65; kd. Yāsin, July 1870; *DIB.* [8] Eur. Letters, II (105). [9] DDn. 91 (539), FD. to STS., 22–6–66. [10] DDn. 93 (239), STS. to Home Dept., 17–10–66; reply 91 (675), 29–10–66. [11] DDn. 91 (733), Home Dept. to STS., 19–12–66.

"It is impossible to reconcile these conflicting statements. If he had originally told the story of being *forced* across the frontier he might have escaped censure and won the reward".

He repudiated Johnson's complaint that he had been superseded by mil. offrs.; he entered the Dept. at the age of 16, when mil. offrs. go to mil. colleges[1], with several years of education and training to come.

After these later claims Walker could no longer support Johnson and his grievances; "No censure could have been more gentle; the words were simply 'Mr. Johnson ought not to have gone beyond the British boundary without the permission of the Government of India'. ... He had no claim to be given executive charge. ... His real reason for quitting the service is...to enter the service of the Maharajah...on salary Rs. 1,500 p.m.".

Govt. accepted Walker's appreciation, but met all Johnson's financial claims, and offered to re-appt. him in the GTS. if he resd. the Māharāja's service.

RGS Progs., XI, 1867 (1–47) describes the reading of Johnson's report of May 1866 at RGS. 12–11–66, where his adventure with its geogl. results were warmly acclaimed, and Johnson was elected Fellow. The attitude of the Govt. of India was chided as churlish. Tennant who attended the meeting felt somewhat out of sympathy[2].

Johnson was posted to the Kumaun & Garhwāl topo. party early in 1866, but resd. in Oct. and moved to Jammu early the following year.

Little is known of his first years in Kashmir service except that he was emp. as engr.; in 1870 he was SE. in ch. of Achnur canal running some 20 m. from the Chenāb SZ. to Jammu but from 1872 he was appd. to succ. Drew as Wazir of Ladākh, where his admin. was greatly appreciated;

"He built for his own residence the first house in European style in Leh, that later became the official Residency. He constructed a commodious *serai* and greatly increased the cultivation. He effected considerable increase of revenue by ...a revenue svy., and improvements in administration.

"He was a man of cheerful disposition, and took an interest in all kinds of nautches and tamashas, despite which he had a high sense of duty and regularity in administration. His darbar used to be open, ...: and no one was refused admission. ... The whole of the proceedings were conducted verbally. There was no formal procedure in law suits. Usually the decision was written briefly on the back of the arzi or plaint, and then handed over to the person in whose favour the case was given. This quick justice and his method of conducting the darbar is still remembered"[3].

Gave invaluable asstce. to Forsyth mission to Kāshgarh, which made Leh its advance base between 1871 and 1873. Kept series of metl. obsns. at Leh from 31–12–72.

RGS Progs., XIX, 1875 (347, 361-3), whilst on leave to England, for his first visit, introduced to RGS. meeting, 26–4–75, by the Presdt., Sir Clements Markham, and by Montgomerie, who both spoke warmly of his services to geography. At later meeting, 24–5–75, Montgomerie accepted a gold watch on his behalf, as Johnson had returned to India where he resumed duty at Leh during Aug.

Montgomerie described him as "a surveyor and explorer from boyhood. As a mountaineer...always conspicuous. No height, no amount of snow or ice were sufficient to deter him if an ascent was necessary. ... The occasion of Mr. Johnson's ascending to 22,300 feet was owing to his inability to get at a valley in any other way except by forcing his way over, and was obliged to spend the night at nearly 22,000 feet above the sea, darkness having come on before he got any lower".

Died at Jammu, 3–2–83, aged 51, after sudden illness, which he suspected to have been from malicious poisoning. He had for some months been telling friends and British officials that he expected an attempt on his life. On that account "his body was conveyed to Lahore and a postmortem...held on the evening of the 4th. Nothing was found to account for death by natural causes, and chemical analysis revealed no trace of poison"[4].

The following is tr. from *K & J. Admin. Report*, Sambat 1939–40 (AD. 1883–4); "In S. 1939 he was transferred from Ladakh, and his appointment to some other suitable post was under consideration when he went on leave to Calcutta. On expiry of his leave Mr. Johnson returned to Jammu where he fell ill. After three days a doctor from Sialkot was summoned...and...his son[5] was informed. Both reached after Mr. Johnson had expired. The body...was carried by his son to Lahore. ...

"The Maharaja...was pleased to sanction a monthly pension of Rs. 100 in favour of Mrs. Johnson".

Later Miss Ada Johnson was allotted a State cottage on the Srinagar bund free of rent till her death in 1943.

JOHNSTONE, Henry Campbell. Ben. Inf. & sc.

b. 27–6–23. d. 30–12–95.

Ens. 31–7–40 Bt. Col. 31–7–71; ret. as M. Gen. 26–6–78.

Son of Dr. James Gardiner Johnstone, MD., and Jane Wilhelmina his wife, dau. of R. Adm. Donald Campbell, RN. m., Dinapore, 2–6–48, Alicia Lawrence, dau. of Lt.-Col. John Jarvis (1796–1849), Ben. Inf., Hodson, III (552–4); she d. 1918, 3 weeks short of 90th birthday.

Sept.–Oct. 1857, comdd. Murree Vols. against local insurgents; 3 medals for mil. service; VC. 1866.

Ubique; Markham's *Abstract* (15); *GJ.* VII, 1896 (209), ob. by JTW.; *SI. Services*; *SI. Notes*, April 1896.

pr. 1848–50, route svy. of Chumba valley, Yarkand country, E. of Mardān; 1851–3, Asst. Ex. Engr. PWD., Sialkot, 27–5–53, appd. by Punjab Govt. asst. rev. survr., joining Shortrede on Jech *doāb*, 19–6–53; Dec. 1858, to ch. dett. for rev. svy. Derajāt, trans-Indus, taking independent ch. with full alloes. Rs. 526 pm., under DSG. from March 1856; much of the svy. was of topo. character, "being carried close up to tribal border with armed guards, and all members of party constantly armed and alert. Johnstone maintained friendly relations with the tribes to a remarkable degree and established great reputation as a frontier officer [4, 48, 218–9, 274, 331, 364, 368, 396–8, 475]".

Dec. 1859, survr. with expn. against Kābul Khēl Wazirs, and again, April–May 1860, with Walker and Baseri, against Mahsuds [217, 219, 540]'.

1–10–61, having completed svy. and mapping of Derajāt, moved party from Murree to Delhi for rev. svy. Ballabgarh, Gurgaon, Rohtak, Hissār, and large-scale svy. Dalhousie Sanatorium [265]'.

1863–4, moved party to rev. svy. Peshāwar, and continued on rev. svy. NW. frontier, with furl. 1870–3 and from 6–5–77, till ret. 26–6–78 [400].

[1] DDn. 93 (256–7), STS. to Home Dept., 33–& 24–1–67, tr. by C. M. Thompson. [2] *Pioneer*, 8 & 27 Feb. & 19th March, 1883. [3] Eur. Letters; JFT. to JTW., 13–11–66. [4] Thos. Geo., BSC., 12th NI. [505]. [5] *Tarikh Jammo* (425), 526). [6] MRIO. 8 (21); Misc. & Rev.; *IO Cat.* (258). [7] Paget & Mason (482,

"Accompanied nearly every expedition which crossed the borders, including...the Ambeyla campaign in 1862, and the Black Mountain expedition in 1868. ... The Hazara field force commenced the ascent of the Black Mountain on 3rd Oct. 1868 and returned to British territory again on 26th idem. Lt.-Col. Johnstone in addition to survey duty was placed in charge of the Intelligence Department, and on him devolved, previous to advance, the discovery of the best routes to the crest of the Black Mountain. The ability which he displayed...and the success that attended his labour have already been fully reported. ... For his services...rewarded... with the...Companionship of the Bath".

"1878, accompanied Sir Sam Browne's column during the attack on Ali Musjid. As his service had expired, much against his will he was obliged to return before the further advance"[1].

Of his svy. of Peshāwar Dist., Markham writes; "The Afreedees asked the meaning of his crest 'the flying spur'. 'In former days [explained Johnstone] men in Scotland were as lawless as the Afreedees, and...when the larder was empty a dish was put before the chief containing only a spur with a pair of feathers fastened to it, being a signal to him and his followers to boot and spur, and be off to raid the cattle over the border, and that the 'flying spur' then became the badge worn by the clan'. The hearts of the frontier Afreedees warmed to the Colonel when they found he was the descendant of the British Afreedees"[2].

KAVANAGH, John Charles. Civ. Asst. Rev. Survr., uncov.

b. 1823/4. d., Fyzābād, Oudh, 19–10–68.

Asst. Rev. Survr., 31–10–46; to uncov. Civ. Service, Oudh, c 1856.

Son of Thos. Henry Kavanagh, of HM. 3rd Ft. (The Buffs)[3], who was reduced from Col. Sgt. to Sgt. in 1828, and d. in Regtl. hospl. at Bhāgalpur, 31–3–29, leaving with regt. his wid. Catherine & 3 children, and a bro. Wm., QMS., quondam actg. band sgt.

HM. 3rd Ft. had arrd. Hooghly R., Feb. 1828 from Sydney, Australia[4].

Wm. Kavanagh d., Meerut, pr. unm., 28–2–40, leaving with regt. as next-of-kin nephews Thomas & John and niece Catherine, *v.* PRO. Casualty Returns. WO. 25/1519. The Regt. looked to the welfare of all three :—

Catherine m., Dehra Dūn, 6–6–42, Henry Keelan of GTS. [*inf.*] and d. there 8–2–73, aged 47 y., 8 mo.

Thomas Henry, junr., was b. Mullingar, Ireland, 15–7–21; arrd. India 1828/9; m., when clerk in Barrack Dept., Ambala, 9–12–44, Agnes (Alice) Mary Courtney, regr. being sd. by John Kavanagh. Appd. 23–6–49, hd. cl. Gen. & Rev. Dept., Lahore; with Henry Lawrence to Lucknow as Supt. AGG.'s office, Feb. 1856; awarded VC. for mil. services during siege, 1857; Asst. Comnr. Fyzābād, 1866; Gonda, 1868; d., Gibraltar 11–11–82; *DNB.*; *DIB.*; *How I won the VC.*, London, 1860; *v.* GRO. *Punjab Lists.*

John Charles m., Ambāla, 15–3–55, Emilia Charlotte, dau. of Chas. Fredk. Hartmann.

Elected member of ASB. 5–2–66.

23–11–42, appd. hd. clerk with Pol. Agent. Ambāla.

31–10–46, appd. Asst. Rev. Survr., cis-Sutlej, remaining after Stephen's departure in 1851 to complete svy. records and maps [269–70, 433]; these records, with series MRIO. Rev. Svy. [270 n.4], bear his comments and signature, and shew him as a well-educated capable survr., and DSG. notes that his "experience and service entitle him to great consideration"[5].

1–10–55, to Sind–Sāgar *doāb* rev. svy. [274], and tr. to Oudh as Asst. Supt. Settmt. Svy.; emp. on settmt. Kehri, Sitāpur, and Lucknow dists, and demarcation Oudh–Rohilkhand bdy.[6] [436, 441].

Thuillier, as Supt. Rev. Svy., records that "on the 22nd January [1861] I visited Lt. Col. Vanrenen in Lucknow District. ... The Settlement Officer, Mr. Kavanagh, also met me, and described the civil work. Mr. Kavanagh, as an old surveyor attached to the Department for many years, and of whom my former reports speak in high terms, is thoroughly acquainted with all requirements of the professional operations [and has given] ... able and hearty cooperation"[7].

Possibly kin to Sgt. J. Kavanagh, asst. overseer, PWD., W. Jumna Canal, Sitāpur, during 1859–60, and to John Kavanagh, buried in RC. cem. Chunār, date not given.

KEELAN, Henry [IV, 384]. Civ. Asst., GTS.; uncov.

b., India, 19–9–17.

d., Mussoorie, 11–5–87.

SAS. GTS. 3rd cl., Rs. 107, 18–5–32...Civ. 2nd Asst., Rs. 259–12–3, 1–8–41; 1st Asst., Rs. 618, 20–5–61; ... Dep. Supt. 3rd gr., Rs. 700...1st gr., Rs. 1,000, 1–4–74; ret. 1875.

Son of Condr. Luke Keelan by 1st wife, Elizabeth who d., Buxar, 5–8–31; Luke m., 2nd. 1832, was inv. Benares, and pens., 3–2–43; living at Monghyr 1862.

m., RC. ch. Dehra Dūn, 8–6–42, Catharine Mary Anne Kavanagh, sis. to John [*sup*]; she d., Dehra, 8–2–73, aged 47 y. 8 mo.; of their many children Henry Elliott served GTS. 1858 till death 1895 [419]; Eugene left a son who was living in Dehra in 1964.

1832, appd. to GTS. at Calcutta, and with Everest on Gt. Arc till 1842 [IV, 384]; then with Gora and Chendwar series and on meast. Sonakhoda base, 1847 [12 n.4, 17 n.1, 20 n.4]; marched Purnea to Dehra with base-line apparatus arrg. April 1848.

Oct. 1848, joined NW. Longl. ser. under Du Vernet and emp. on minor trgn. which incl., 1851, remarkable line up Sutlej and Spiti rivers to Bārā Lācha La [5, 35–6, 200–4, 206, 286, 422–3, 474]. After survg. SG.'s route to Peshāwar 1851–2, joined Logan on Rahun ser. [50, 185, 202, 403].

1853–4, on meast. Chach base, and on Logan's death took over ch. of No. 2 Hill Ser. at Lahore to conduct apparatus to Karāchi by bullock cart, a formidable journey during the hot weather [43–4, 158, 371]. Handed over to Strange and asstd. in work on base-line; "Mr. Keelan's assistance was so valuable that I do not think the preparations could possibly have been completed without his help"[8]. Keelan asstd. at meast. of 5 base-lines in all [43–4, 158, 371, 511 n.1, 532].

Now under Lane, marched up from Karāchi to Dehra and emp. season 1855–6 on Rahun ser., taking over ch. for season 1856–7. March 1857 ordered to hdqrs. to fix position and height of Kamet [86]; "owing to this timely diversion...the party had just time to get through the Delhi District, and thus escape inevitable destruction" [50, 482][9].

Owing to disturbed state of the country the Rahun party was kept at Dehra Dūn throughout season 1857–8, and on 1–9–58 Keelan handed over ch. to Tennant and joined the Gt. Indus ser. from Dehra Dūn, travelling by river from Ferozepore to Sukkur, where he took over ch. of s. section from Armstrong [48–50, 138][10].

To save marching and counter-marching he made recess quarters at Mithankot throughout hot weather of 1859, completing apprx. ser. and building 18 towers. He completed

[1] *GR Rev., 1868–9* (60); *SI. Notes*, April 1896. [2] Markham's *Abstract, 1869–70* (15). [3] enlisted at Dublin 27–7–04; PRO.; PL & M. Rolls, WO. 12/2121/2, 1828/29. [4] PRO.; MR-WO. 17/386-105, 414. [5] DDn. 665 (63), SG. to DSG. 21–6–55. [6] MRIO. 16 (26), sd. by Kavanagh as Asst. Supt. Settmt. [7] *GR Rev. 1858–60* (105). [8] DDn. 613 (19), 2nd. Hill Ser.; 612 (74), Strange to SG., 2–2–55. [9] DDn. 692 (77), Keelan to GTS., 26–8–61. [10] DO., 9–8–58.

junction with N. section under Basevi, and marched back to Dehra by May 1860 [49, 100, 110–1, 367][1].

1860–3, in ch. Rahun ser., having son Henry Elliott as asst. during last two seasons. 4–3–61, recdd. for promotion to 1st Asst. in recognition of excellent work [408, 416].

From 1863 held ch. of trig. parties of SE. Quad.; Sambalpur merdl.; revision of Calcutta longl., and Bilaspur merdl. On attaining age of 55 in 1872 agreed to serve a few years longer, but later protested against move to Burma;

"At my time of life...it would not suit me. ... I am too old now to take up new work in a foreign country, and as I have a couple of years longer to serve to entitle me to the superior pension, I beg you will allow me...furlough for 2 years from the 1st of November next, at the end of which time I intend sending in my papers to retire from the service"[2].

As time-expired officers were not entitled to furl., he submitted appn. to ret. in Dec. 1874, giving the following particulars; Son of Luke Keelan—Protestant—proposed annual pension Rs. 5,256—to be drawn at Dehra Dun—birth, 19–9–1817—height 5 ft. 7 inches.

Settled in his house, Meadow Bank, No. 41 Dehra Dūn, on E. side of Rājpur Rd. opposite St. Thomas' Ch.[3], where his g. son saw him in 1885.

LANE, Charles Richard [IV, 384]. Civ. Asst. GTS.; uncov.

b., India, c. 1–6–17. d. Calcutta, 7–11–83.

SAS. GTS. 3rd. cl. Rs. 107, 14–5–32...3rd Prcpl. Asst. Rs. 323, 31–3–45, Ch. Civ. Asst., Rs. 600, 7–5–56; to Rs. 800 pm., 1–10–64; ret. 1–10–71.

Nat. son of Chas. Wm. Richd. Lane (1786–1872), Ben. Inf., Capt. 30–1–24, Gen. 25–6–70, who m., 1st., Calcutta, 18–3–29, Miss Ursula Palmer, Hodson, III (10–1); bro. to Wm. Lane of rev. svy. [IV, 399; V, *inf*].

m., Benares, 2–10–48, Jemima Elizabeth, dau. of Thos. Milner [369 n.2].

1832, appd. to GTS. at Calcutta, serving successively on Amua, Karara, Gt. Arc, Ranghir & Calcutta ser., and on E. section of NE. Longl. [14–5, 367, 402, 419]. Took ch. of Maluncha ser. on death of Walker [19]. With SG. on Darjeeling trgn. 1847, obsg. from Rāmganj polygon, incl. one ray to peak *gamma*, which was later called Pk. XV, or Mount Everest [17, 20, 30, 82–3, 86, 91–3, 406]. After conng. Sonakhoda base accd. old Maluncha party to Sironj under Renny to Gt. Longl. ser., and with Strange to Karāchi, his long experience proving of utmost value [37, 38, n.4, 41, 361–2, 405].

16–5–50, submitted memorial to GG. seeking promotion to fill Peyton's place [520], giving colourful sketch of survr's life; "The tent...is his home, and the jungles his locality. Alike subject...to exposure to the hottest Indian sun throughout the day, and extreme cold and dew at night. Liable to work both by day and night, and without intermission. No fixed times of business but amenable to all hours, cheerfully plodding through every toil and privation of a constant marching life, from the healthy to the deadliest miasmatic regions of India, places frequently shunned by almost every description of living creature"[4].

In declining to forward this memorial, Waugh objected to its style and spirit; "I am resolved not to promote any grumblers. ... After all, what are the hardships endured by Mr. Lane to those of the old surveyors"[5] [403, 415]?

1854–5, with Tennant for connection of Gt. Indus ser. and meast. of Karāchi base; took over ch. of 2nd Hill Ser. from Strange, marching it up from Karāchi to Dehra Dūn, and then taking up Rahun ser. 1855–6 [44, 50, 345, 480].

7–5–56, succ. as Ch. Civ. Asst. on ret. of John [illegible].

Oct. 1856, tr. to ch. Assam Longl. the journey to Goālpāra taking from 4th Oct. to 12th Jan. The Assam party had suffered greatly from continual sickness, and consequent changes of staff. Lane found progress difficult and slow, and made lengthy complaints [2, 31, 120, 415, 461–2, 482].

The SG., however, gave him full credit for his two first seasons in Assam; "Not only had he to combat with climatic and physical difficulties of no ordinary character, but the reorganization of an establishment crippled by death and disease devolved on him. ... Considering all these circumstances...I recommend him to Government for an additional Rs. 268 per mensem, to make his salary equal to that of a Lieutenant in the army and 1st Assistant G.T. Survey"[6]. He was promoted to Rs. 800 pm. six years later.

Taking 4 mo. sick leave during season 1859–60, he carried the ser. S. ward towards Sylhet as the E. Frontier ser. till in 1865 he took furl. [32–3, 415].

From 31–8–66 held ch. of a levelling party in Central India till ret. on annual pension Rs. 5280, to be drawn at Benares; "eyes light blue; height 5 ft. 5 in.".

LANE, William [IV, 399]. Civ. Asst., Rev. Svy.; b., India, c. 24–9–21. uncov.

SAS. Rev. Svy., 10–2–37...Asst. Rev. Survr. 1846; Dept. Supt. 2nd gr. Rs. 900, 10–2–71; ret. 1876.

bro. to Chas. Richd. of GTS. (*sup*).

m., Simla, 17–8–48, Sarah, dau. of Isaac Lemon; their son, Wm. Lemon Lane, b., Simla, 28–5–50; another son(?) Wm. James, was appd. to rev. svy., 1–3–65.

1837 to Jan. 1843 with Bhāgalpur and Midnapore rev. svys.; Jan. 1843 to June 1844, sick leave to Europe; with Tirhut rev. svy. till resd. 17–11–46; "Mr. Lane has had delicate health ever since he joined this Survey, and during the last recess has been suffering from dysentery and other complaints"[7]; mc. advised empt. "in the Upper Provinces as essential to the preservation of his health" [438].

4–12–46, appd. Asst. Rev. Survr. trans-Sutlej rev. svy.; 1851–2, held ch. of camp in Kāngra Hills, and work praised by SG. [273, 433, 435].

2–11–52, in ch. No. 2 camp, *pargana* Tulwundee, Rechna *doāb*, and from 1855, with Macdonald to Sind. Early 1856, held ch. of svy. round Karāchi for rlwy. purposes [277, 279], and 1856–7, held ch. of camp in S. Sind [8]. 22–4–60 till 24–8–61, held ch. party hdqrs. Sukkur, during Macdonald's furl.

ch. No. 2 party Sind rev. svy. till he took furl. 21–6–67 to 11–8–69, being then appd. to ch. Kyaukpyu, Burma, 1869–70; ch. Azmgr., Midnapore, CE., 1870 till ret. 1876.

LAUGHTON, George Arnold. Bo. Inf.

b. 16–5–30. d. 1–5–1912.

Ens. 3–7–46 ... M.Gen. 6–2–87 & USL.; Lt.-Gen. 1891.

Son of Richd. Laughton, Ben. Med., and Ann Agnes his wife.

m., 1st., Belgaum, 18–10–58, Euphemia, dau. of late Capt. Erskine, HEICS; 2nd., 1880, Annie Barbara, dau. of Rev. J. S. Beaumont, of Edinburgh.

Markham, 1871 (299); *Bo. Services, 1883*; *Who Was Who.*

19–12–51, appd. asst. rev. survr. SMC., joining 5–1–52. 20–10–56, fd. service, Persia; 21–8–57, with regt. Belgaum. 18–9–58, resumed svy. appt. SMC.; 1–4–61, ch. Berār rev. svy.

[1] DDn. 701 (308), JTW. to SG., 5–6–60. [2] DDn. 158 (175), to STS., 15–6–74. [3] GBO. Lib., map 1 (4), Plan of Dehra, 1868. [4] DDn. 708 (51). [5] DDn. 616 (86); SG. to Strange 21–8–50. [6] DDn. 643 (237), to Mil. Dept., 30–7–58. [7] BRC., 11–11–46 (18). Wyatt to DSG., 12–10–46.

1862–4, furl.; 1864–9, ch. Thāna & Ratnāgiri; 1869–70, furl. 27–9–70, Supt. rev. svy. Bombay Inland & City; 8–9–77, Asst. Supt. Poona & Nasick; [1] 6–10–80, Supt. rev. svy. Karāchi city [398, 401].

LOGAN, George [IV, 454–5]. Asst. GTS.; b., Scotland, c. 20–5–09. uncov. d., Mussoorie, 10–6–54; MI., cem. and Christ Ch.

ch. SOO. Obsy., 11–3–31; 2nd. Astr. Asst., 16–1–34; 2nd. Asst. GTS., 3–10–36; 1st Asst. 17–6–42 [419].

Son of Thos. Logan of Duns, Berwick, and Elizabeth his wife; *v. History of Logan Family*, Edin. 1934.

m., Mussoorie, Charlotte Jane, dau. of James Manson 1791–1862), Ben. Inf. [III, 484]; she d. 1900.

arrd. India, 22–9–30, related to James Herbert (1791–1833), Ben. Inf., DSG. [III, 457n8].

1834–42, emp. on Gt. Arc; 1843–50, in ch. Chendwar ser. and w. section of NE. Longl., becoming, after Renny, Waugh's most trusted officer [402, 410]. Took numerous obsns. to snow peaks, but none so far E. as Mt. Everest; assd. at meast. Sonakhoda base [12–3, 16–9, 20–1, 30, 65, 81–2, 84–6, 90–2, 104, 119, 126, 132, 149–50, 153, 156, 161, 296, 341, 361, 366, 382, 412–3, 417, 457].

Recess qrs., 1844 Patna, 1845–6 Monghyr, 1847–8 Digha Ghāt, Dinapore [13 n.3]; from 1849 Mussoorie [368–9].

Oct. 1850, moved party to NW. Longl. ser. carrying it from E. of Jammu to close on Chach base nr. Attock [2, 202, 209, 215, 363, 375, 379, 469; pls. 3, 5, 7]; Feb. to April 1852, obsd. first two polygons of Gt. Indus ser. S. of Attock [3, 36–7, 44].

1852–3, started Rahun ser. S. through Patiāla and Hissār, falling sick for two months; 1853–4, took party to assist at meast. Chach base, the 6th he had attended[1] [42–3, 50, 63, 110, 157, 383]. On return march again seriously ill and left party at Lahore for Mussoorie where he died a few months later [43, 50, 408, 414, n.3].

"Mr. Logan's health failed him very much previous to, and during, the measurement, ... and he was strongly advised by the medical authority to seek change of climate, and not to exert himself in the manner he did from sunrise to sunset. This zealous officer, however, would on no account abandon his duties, and by way of setting an example...he resolved to face the climate of Sind in all its severity by marching with the base-line apparatus from Attock to Karachi. On reaching Lahore, however, the disease under which he was suffering (dysentery) prostrated him to such a degree that he was forced to...relinquish the duty"[2].

At time of his move to Punjab in 1850, the SG. told Govt. that he was "second to no officer in the Department in skill and ability, while...conducting his work always on the most amicable relations with the people of the country by whom he is greatly respected. ... His establishment is a perfect model of good discipline and correct behaviour, and the sub-assistants under his charge have always been trained in habits of business and moral propriety"[3] [10, 342, 346, 362, 393, 414].

LUMSDEN, Peter Stark. Ben. Inf. & SO.
b. 9–11–29. d. 9–11–1918.
Ens. 10–12–47...Bt. Lt.-Col. 21–8–66...
Lt.-Gen. 8–1–87; USL. 9–11–96.

Son of Col. Thos. Lumsden (1789–1874), Ben. Art. [IV, 130, 436], and Hay, dau. of John Burnett of Elrick; bro. of Sir Harry Burnett Lumsden (1821–1896) of the Guides, *DNB.*; *DIB.* [475].

ed. Addiscombe.

m., 1862, Mary Margaret, dau. of John Marriott, of N. Beechley, Lancs.

CSI. 1870; KCB. 1879; GCB. 1885. *DIB.*

auth. of *Lumsden of the Guides*.

1853, as DAQMG. made recce. sketch up to head of Kāgān valley which Robinson incorporated into revised map of Hazāra [209]. SG. refers to this when applying to QMG. for his services with Kashmir svy. "As that officer has a special knowledge of the country in the Numsook valley and head of the Kishenganga, his previous experience may be ...valuable in surveying the tract. ... So employed he would be almost, if not quite, as near his official post at Peshawar as with Lieutenant Robinson, and could rejoin nearly as soon by the Bara Moolaa pass via Moozafarabad through Hazara"[4].

1855–6, with Garnett [215 n.1, 217, 488, 498], on recce. in Upper Miranzai and Kurram; *IO Cat.* (467).

April 1856, from QMG.'s Dept. at Peshāwar, reported to Montgomerie at Srinagar, and with Allgood and Johnson on pt. svy. in open country of E. end of Kashmir valley. His 2nd board lay W. of Kolahoi, covering Srinagar and Mahadeo, his drawing being "particularly artistic". In Sept. recalled for duty under FD. [225–6, 229, 231, 388, 400].

1857–8, with his bro. on diplomatic mission to Kandahār; "their movements were jealously restricted, and little or no actual surveying work was executed. They returned to Peshawar in June 1858"[5]. On the march up, however, Lumsden was able to sketch Kurram valley, with view of Safed Koh [217, 330; pl. 2][6]. He also compiled rough map of Kafirstān and Yarkund "from Kaffir information"; *IO Cat.* (466–7, 473).

Had distinguished mil. career; QMG. 1868–73; AG. 1874–9; Ch. of Staff, India, 1879; Council of India, 1883–93; Comnr. for demarcation of Russo-Afghān bdy., 1884–5.

MACDONALD, Donald. Ben. Inf. & SC.
b. 10–12–35. d. 27–3–1918.
Ens. 20–10–53, ... to SC., 13–8–64; Lt.-Col. 20–10–79; ret. aged 55, 10–12–90; Bt. Col. 28–10–83.

Son of Gen. John Macdonald (1802–95), Ben. Inf., Hodson, III (123–4), and Catherine his wife, dau. of John Matheson of Attadale.

m., April 1865, Emilia Frances, dau. of Lt. Crommelin, RA.

Times, 4–4–1918; *SI. List.*, 1–7–81; *SI. Services*, 1–1–84.

arrd. India, 11–12–53; sick leave to England, 20–5–59 to 12–8–60; GO. 19–10–60, appd. Asst. Rev. Survr.; joining No. 2 Div., Manbhum, 29–10–60; with ch. 16–12–63 to 1866 [396, 400].

Dep. Supt. in ch. rev. svy. parties, Assam, Sind, Karnāl, Hissār, taking furl. 1872–4; 1883–4, ASG., Calcutta; furl. from 1–12–89 with tr. to Mil. Dept. at age of 55.

MACDONALD, John. Ben. Inf. & SC.
b., Salem, 11–5–29. d. 9–9–1903.
Ens. 11–12–46 ... Bt. Col. 11–12–77;
ret. as M. Gen. 13–12–80.

Son of Chas. Edw. Macdonald, MCS. and Maria Agnes his wife, dau. of Edw. Stevenson; g. son of John Macdonald (1759–1831) [II, X, 469], Ben. Engrs., FRS. *DNB.*; Hodson, III (122–3), Conolly (84/57).

Father of Chas. Macdonald, Capt. 6th Ben. Cav. *Clan Donald*, III (578).

1851–2, Ex. Engr. PWD., Ferozepore.

10–9–52, appd. by Punjab Govt., without ref. to DSG., Asst. Rev. Survr., Upper Rechna *doāb* under Shortrede; tr. Jan. 1854 to Thos. Blagrave's party,

[1] earlier lines Calcutta, Dehra, Sironj, Bidar, Sonakhoda. [2] DDn. 643 (19), Report, 2nd Hill Ser. [3] DDn. 542 SG. to Mil. Dept., 20–8–50. [4] DDn. 713 (108), 9–2–56. [5] *Geo. Mag.*, I, 1874 (4). [6] MRIO. Misc., 13–0–58; *RGS Progs.*, 32, 1862 (304).

taking ch. at Lahore from 9-1-56 and moving party to Upper Sind [7–8, 194, 274, 277–9, 365, 425].

23-4-60, furl. on mc., sailing from Bombay 11–5–60, returning Bombay 8–8–61, Sukkur 24–8–61, [396–7, 400, 510].

1–4–66, Dep. Supt. 1st. gr., in ch. No. 4 Div. GP.; 1867 offg. Supt. Rev. Svy. LP.; and also 1868, offg. Bdy. Comnr.; *ASB. Progs* 1868 (215–8), obsd. solar eclipse at Baijwarra, on Kistna R. c. 20 m. E. of Guntūr.

Home Dept. 9–12–69, to pol. duty on Cāchār frontier; on pol. and svy. duty Lushai & N. Chittagong Hills; 1871–2, offg. DSG. in ch. SURVS. with Chittagong col., Lushai expn.; "Attached himself to the 2nd Goorkhas throughout the campaign, and took part with them in all their encounters with the enemy. On return from expn. resumed, duty as Supt. Rev. Svy., Lower Circle; Nov.–Dec. 1872 on bdy. svy. Assam-Bhutān; 1873–4 furl[1].

Govt. letter, 16–10–76, to SG. censured Macdonald who had admitted authorship of several letters to press criticising 3rd edn. of *Manual of Surveying in India* [284] as "utterly useless as regards professional work of the present day", and for omitting all ref. to Radhanath Sickdhar[2] [521].

Under this reprimand Macdonald was suspended from admin. office; reverting to ch. N. Deccan topo. svy. took 2 y. furl. from 6–5–77 and on return resumed ch. N. Deccan 6–5–79 till 13–11–80.

MACLAGAN, Robert. Ben. Engrs.

b. 14–12–20. d. 22–4–94.

2/Lt. 10–12–39 ... Lt.-Col. 18–2–61

Lt.-Gen. 1–10–77; ret. as Gen., 31–12–78.

Son of David Maclagan, MD., phys. to Forces during Peninsular War, and Jane, dau. of Dr. P. Whiteside.

Blackwood's, Aug. 1894, biog. note by W. Broadfoot; Conolly (89/202); Sandes, II (358–62), with portrait.

1842–3, road-making in Himālaya; May 1843, on Delhi Canals; Aug. 1843, with Baker to Sind; 1844 measd. base-line nr. Karāchi [192]; 1846, 1st Sikh War. Cunningham, *Ladak* (pref. vii), ackn. Maclagan's svy. in Spiti valley, date unk.

1847–60, Prcpl. Thomason Coll., Roorkee; 1861–79, CE. Punjab.

MARKHAM, Clements Robert.

Geogr. and Historian.

b. 20–7–30. d. 30–1–1916.

Cadet, RN., 18–7–44; Mdpn. 26–6–46 ... ret. as Lieut. 28–12–51. Clerk, Inland Rev., Dec. 1853; 10., July 1854. ... Asst. Sec., 1867–77; Geogl. Dept. from 1863; ret. on pension 1877.

Son of Rev. David Fredk. Markham, Canon of Windsor and from 1838 Rector of Gt. Horsley, Essex, and his wife Catherine Frances Nanette, dau. of Sir Wm. Milner, Bart. of Yorks.

ed. Cheam and Westminster, 1842–4.

m., 23–4–57, Mary Ann, dau. of Rev. J. H. J. Chichester, rector of Arlington, Devon.

CB. 1871; KCB. 1896; FRS. 1873; FRGS. 1854; Hon. Sec., 1863–88; Gold medal, 1888; PRGS. 1893–1905; Sec. Hakluyt Soc., 1858–87; Hon. ScD. Camb. 1907.

Auth. of *A Memoir on the Indian Surveys*, 1871; 2nd edn. 1878; *Catalogue of MS. & Printed...Memoirs and Maps of the Indian Surveys*, 1878; *Narrative of the Mission of George Bogle to Tibet*,—appx., tr. of Desideri letter on march to Lhāsa [240]—; 1879 several *Abstracts* of reports on Indian Surveys, and other works of geogl. interest.

Ency. Brit.; *DNB.*, suppt. 1912–21; *DIB.*; *OW.*, I [620]; ob., *GJ.* 47, March 1916 (61–76); *Nature*, 96, Feb. 1916 (627–8).

1850–1, whilst with RN., on arctic expn.; 1852–4, travelled in Peru; 1859–62, introduced cinchona (quinine) to India[3]. 1868, with expn. to Magdala, Abyssinia.

From 1863, on SG.'s suggestion, entrusted with geogl. affairs of IO.; and assumed colossal task of reorganizing geogl. br., arranging and listing collns., pub. periodical reports on Indian svys. His *Memoir* has long been standard history of the Dept. and of geogl. work in India [xv, 268, 280, 302, 381]. Account of Geogl. Dept. of IO. 1867–77 is given on pp. 399 to 423 of 2nd edn. of *Memoir*.

Survey of India is deeply indebted to Sir Clements Markham, not only for his work at IO., and his pub. *Memoirs* and *Abstracts*, but also for the stimulating influence he exercised on work of the Dept. for nearly forty years [502, 509].

MELVILLE, Alexander Brodie. Ben. Inf.

b. 26–2–35.

d., Mymensingh, Bengal, 15–2–71.

Ens. 10–12–52 ... Capt. 12–9–66; refused tr. to sc.

Son of John Melville of Upper Harley St.

ed. Rugby from Aug. 1849; nominated for Addiscombe but resd.

m., Dehra Dūn, 27–3–65, Matilda Jemima, dau. of Lt.-Col. A.W. Chichely Plowden, sister of Pauline Godwin Austen [488], who witnessed her marriage.

23–3–57, applied for appt. to Kashmir svy., "I have been at the Thomason College, Roorkee, for nearly a year, and have completed my surveying course and obtained the certificate"[4].

18–4–57, nominated topo. asst. Kashmir Svy.; "on probation"; joined from Roorkee, Dehra Dūn 23–4–57, Srinagar 3–6–57 [227, 389]. After instn. by Montgomerie "sketched a large piece of high ground at the head of the R. Liddar, including several glaciers". "The rapidity and way in which the work was done is very creditable; ...it required great perseverance and good management". He then surv'd. 67 sq. m. on Kishanganga R., to complete total of 1,300 sq. m. on 1-inch scale [229].

With Austen and Murray sood. party to Dehra Dūn for cold weather. They were all brought on to permt. strength of GTS. as Topo. Asstt. from 22–2–58, when they took the fd. again [389]. Melville now surv'd. 690 sq. m. in the sandstone hills east of Jammu and then moved to Tithwāl on lower Kishanganga. In August he moved to R. Chenāb valley near Chamba [230–2].

He tells of hot sulphur spring which he saw during 1858; "situated in the village of Burmunadul about a mile north of Kalutrote. There are two springs close together, the temperature of the upper was 116° Fahrenheit. The water was beautifully clear and gave out a very strong smell of sulphur. The thermometer gave the height of the spring 2,518 ft. "The spring is much used for thermometic complaints, which it appears to be successful in curing. There is the remains of a serai sort of place built for the accommodation of bathers.

"The spring and one or two huts about are called the Jutta Pani. The natives have a curious story. They say that 15 years ago it dried up for a whole year, and that during that year a hot spring broke out at Harpoor near Bhimber [pl. 13]. After the year was out the old spring began to flow again and the one at Harpoor dried up.

[1] *GR Rev. 1872–3*, LP. (49), report sd. 17–6–73. [2] *Govt. letter pub.* in *Gaz.* and *Friend of India*, 11–11–76; Macdonald's letters in *Pioneer*, 22–4–76; *Friend of India*, 17 & 24–6–76. [3] Auth. of *Travels in Peru and India*, pub. London, 1862. [4] IDs. 51 (23), TOM. to SG., 28–3–57.

"Close to the spring a seam of coal, or what appears to be coal, crops out, and I observed it in several other places in the ravines near the spring. All the rocks about appear to have been much disturbed. I brought away specimens of the coal. The spring and the seam of coal are mentioned by Mr. Vigne in his book[1]". Ferguson (157) describes similar spring, Sundra Brari, at E. end of valley.

May–June 1859, with Ryall, made 2-inch svy. of Srinagar, later reduced to half-scale [232, 233 n.4 239]. Then survd. country drained by Drās R., beyond Zoji La towards Kārgil, and "completed a large tract...on the Sooroo R. and its branches on ½-inch scale". At end of August had to break off owing to ill health and came in to Srinagar to finish up drawing and hand-printing of fd. sections [233].

During March 1860 to the Pabhi hills nr. Jhelum, making "a most workmanlike sketch of this difficult piece of country" that was incorporated into Shortrede's district map of Gujrāt [273]. Then marched to Kashmir and during May survd. first to N. of Hari Parbat, and then to the upper Kishanganga, W. of Gurais, where he was much troubled by snow[2].

In July took up work along the great range between Ladākh and Wardwān, and sketched the "Kun and Nun peaks", 23,500 feet above the sea[3], and their numerous glaciers, besides the terrific country N. of the Brāma glacier [235]. "A capital season's work. ... "The geological knowledge which both Captn. Austen and Lt. Melville possess will be of use as the rocks of the highest peaks are not known for certain".

During 1861 survd. Zānskār valley and range running E. & W. between Indus and Gt. Himālaya range. Returned to Dehra through Chamba "instead of returning to Kashmir as usual. I propose now remaining here...and...working up my planetable section, making the duplicate, and working up my notes, routes, etc., ... which will give me plenty of occupation until the Kashmir party arrives"[4].

During past two seasons took a large number of photographs, "some of the views taken by him of glaciers and the bare rocky ridges...being particularly definite and characteristic". They included the village of Padam[5] [141, 331].

Nov.-1861, Montgomerie recdd. him and Austen for promotion to Rs. 618 as full survrs.; besides their excellent topo. work they had "learnt the use of the theodolite and taken share in the ordinary computations of the party". This promotion did not come till 1865[6] [389–90].

1862, taken ill on march up to Ladākh, and returned to Srinagar where he was "employed on office work, photography, etc.". During recess at Dehra asstd. on compe., "and continued his practice of photographing maps. He succeeded in taking admirable negatives of the maps of Jummoo...and Little Tibet, reproducing them on the scale of the originals"[7] [237].

Starting into Ladākh in summer of 1863 he again fell ill, and got back to Leh with great difficulty; he was helped in and doctored by Ryall, who was also very ill himself. His 1-inch svy. of Leh appears on sheet 18 of 1868 map of Ladākh, *IO Cat.* (257) [239 n.7].

Oct. 1863, tr. from Kashmir for ch. Gwalior & CI., topo. party, taking over at Dehra from Robinson 10–11–63[8], and holding ch. with occasional intervals till tr. to PZO. at Dehra "to study the process of photo-zincography under Mr. Hennessey [330–1, 502] ...Capt. Melville is an excellent photographer". March 1867 took over ch. of the map office at Calcutta[9] taking leave to England, Feb. 1869 [501 n.4].

Returning from leave in Jan. 1871, he was on his way to take ch. of Khāsi & Garo Hills svy., when he d. suddenly at Mymensingh; *GR Topo. 1869–70*; *1870–1* (21).

MONTGOMERIE, Thomas George.

Ben. Engrs.

b. 23–4–30. d., Bath, 31–1–78.

2/Lt. 8–6–49 ... Lt.-Col. 1–7–74; ret. as Col. 10–3–76.

Son of Col. Wm. Eglinton Montgomerie of Annick Lodge co. Ayr (1789–1852), and his wife, Susannah Fraser, dau. of John Anderson; gt. nephew of 12th Earl of Eglinton & Winton. An uncle, Thos. Montgomerie (1796–1819), served in Ben. Art., 1814 till death in Calcutta, Hodson, III (316). ed. Addiscombe; Pollock Medal, 1849.

m., England, 11–2–65, Jane, dau. of M Gen. J. J. Farrington (1790–1858), Ben. Art., Hodson, II (165–6); she d. 20–7–1916, leaving son, Hastings Seton Montgomerie (1872–1949), of Gray's Inn, London, TD., auth. of *William Bligh of the Bounty*, pub. London, 1937, who d., London, unm.; one son d. on 3rd day after birth, Mussoorie, 11–9–69; the yr. of 2 daus. d., Bath, 1952.

FRS. 1872; FRGS. Founder's gold medal, 1865; annual Montgomerie Memorial Prize, RE. Instn.

DNB.; *DIB.*; Conolly (91/267); Debrett, *sv.* Eglinton 1945 (372); Burke, 1932 (919), 1956 (747–8); Markham (427–9); *Ubique*; *REJ.*, VIII, 1878 (29–31); *JRGS.*, 48, 1878 (cxlv–viii); *RGS Progs.* X (164); XXII (317–20); *Geo. Mag.*, IV, 1877 (123); *Addiscombe* (568); *GR Trig.*, 1875–6 (3–4), note by Hennessey; Yule, I (168); Burrard & Hayden (56–8); Sandes, II (200–1, 231–3), with portrait; Mason (76) with portrait;

Portrait from photo-group, Calcutta 1861 [340 n.3, 517, pls. 20, 23].

arrd. India, June 1851; appd. 2nd Asst. GTS., 20–8–52, joining 1–10–52; 1st asst. 24–3–54. In appn. for appt., notes that he had "read the usual engineer course of mathematics, including spherical trigonometry, differential and integral calculus, and the rudiments of astronomy"[10].

1852, with 5th Co. S. & M., emp. on Hindustān-Tibet rd. writing to SG. from Kasauli, 28–9–52; "I have this day been relieved from the charge of the Dagshai Division of the Hill Roads and...start this evening per dak to join your headquarters at Masouri"; 9–11–52, joined Rahun ser. under Logan [50 n.3].

1853–4, asstd. at meast. Chach base, obsg. triangles of verification with Barrow's 3-ft. theodolite [43, 150]. Oct.–Nov. 1854, with SG. on boat journey down Sutlej to Karāchi —leaving SG. sick at Mithankot—emp. under Strange on meast. base-line, Dec. 1854 to Jan. 1855 [44, 399].

Selected in Sept. 1854 for ch. Kashmir svy. [3, 221, 361, 363, 380–3]; "After the measurement of the Kurrachee base I proceeded up the Indus in a river steamer leaving Kurrachee on the 24th of January and reaching Mooltan on the 13th February. From Mooltan I went to Lahore to...[consult the Punjab Govt.]. From Lahore I went to Umritsar where I found on 23rd. February the party under Mr. Johnson"[11] [208, 222, 480].

The party left Amritsar on 2nd March, and followed Bari *doāb* canal. to headworks on the Rāvi

[1] DDn. 715 (477), 3–5–59; not located. [2] DDn. 717 (156), 19–6–60. [3] Ser and Mer [87 n.4]; Ser or Nana [pl. 6]; Brama Pk [pl. 13]. [4] DDn. 53 (77), Melville to STS., DDn., 23–9–61. [5] *GTS. Syn.*, VII (xxxii—C). [6] DDn. 51 (80), TOM. to STS., 29–11–61. [7] *GR. Trig., 1862–3* (4n.); *GTS. Syn.*, VII (xxxv—C). [8] *GR Trig. & Topo. 1864–5* (Appx. A, i–iv), Melville's narr. Nos. 1 & 7 Parties. [9] *IO Cat.* (177), Chittagong map photo. by Melville, 1867. [10] DDn. 545 (101), TOM. to SG., 12–5–52. [11] DDn. 609 (227), TOM. to SG., 11–4–55.

near Madhupur [pl. 13], where they crossed into Jammu territory[1] to reach Gurhagarh RS. The heavy baggage, the 24-inch theodolite, and the sepoy guard were dropped, and the adventure started by climbing Saraoli peak, 8,177 feet above sea [222].

With only two assts., Johnson and Douglas, he now carried prcpl. triangles across Pir Panjāl range. After selecting first four stations, Montgomerie returned to make final obsns. leaving Johnson to complete lay-out over the top and into Kashmīr valley, [222–3, 505].

Started obsns. at Gurhagarh on 20th April, working with 14" theodolite in preference to 24" that was too cumbersome for mountain work [157]. After arduous climbing often in tempestuous weather, he completed his meticulous obsns., sleeping many nights together within 200 yds. of summits up to 15,000 ft. with snow often 10 ft. deep. "The rigorous rules of the GTS. were not in the least abated" [5, 10, 286–7].

"Occasionally, in consequence of clouds and storms, the party had to remain pitched on the snow for upwards of a week at a time. On the Pir Panjal peaks the electricity was so troublesome even when there was no storm that it was found necessary to carry a portable lightning conductor for the protection of the theodolite [223–4].

"Even for our very small camps sufficient space could never be got quite close to the stations on the peaks. During the day this did not matter, but at night...it was rather a difficult matter to get back from the observatory tent after ...taking observations to the lamps. Soon after sunset the surface of the snow became as slippery as glass, affording by no means a satisfactory footing on a narrow ridge with precipitous slope, or a precipice on either side" [224][2].

After this battle with the elements it was a relief to descend into the valley, and to march into Srinagar on 21st July. Outdoor work was resumed in mid-Aug., but was constantly delayed by clouds and mist. After extending triangles westward across the Wular Lake, Mountgomerie and Douglas followed the Jhelum and visited Murree. He reported that the road might some day be made fit for laden camels [224].

At this period the main route into Kashmir was via Jammu and Rājaori, and over the Pir Panjal pass, and Montgomerie describes the main passes into the valley;

"The Pir Panjal pass, though a very high one [11, 462 ft.] involving a halt on nearly the highest part, is much used for traffic, partly because there are but 4 or 5 severe marches on the road between Aknoor and Srinagar [pls. 6, 13], and partly no doubt from the ease with which Thanna may be reached from the plains [IV, 291 ; V, 224, 228 ; pl. 13].

On return journey to Dehra Dūn called on the Mahārāja at Akhnūr, and reached Siālkot on 1st Nov. [370].

In 1856 with party increased by more assts., and with 3 mil. officers to join in Srinagar for topo. work, Montgomerie left Dehra 4th March, reported to the Ch. Commr. at Lahore and reached Jammu 11th April. Left 15th; "Saw the Maharajah yesterday afternoon. ... My traps left this morning and I...hope to be in the valley before the end of the month [480–1]. "Johnson...is to go by the Banihal route; I am going by Rajauri. Brownlow is flourishing; we are both quite delighted to be en route once more[3]" [225, 404].

They reached Srinagar 30th April, and Montgomerie spent May starting off his assts., and instructing his mil. officers [425, 488]. He then took Brownlow with him to complete obsn. of the main triangles west of Srinagar, being much interrupted by rain. In Sept. he sent Brownlow on trgn. down the Jhelum valley, and himself climbed Haramukh, the massive height some 22 m. N. from Srinagar, the starting point for the N. ward extension being about 900 ft. below the summit [88, 225 n.3].

It was from this point, on 10th and 11th Sept. that he got his first view of the Karakoram range at distance of nearly 150 m. He took horizontal and vertical angles to two great peaks which he sketched in the margin of his angle-book [89, 225–6]. For identification purposes he dubbed them K 1 and K 2, K 1 being the nearer and more prominent though 2,600 ft. the lower.

We find no confirmation of the story that he commented to his recorder "Babu, We have shot the Giant", or even "That is the Giant"[4]. For one thing, he had no "babu" with him, his recorder being Wm. Beverley; and his sketch shows no appreciation that K 2 was the giant. His official report records that "these two peaks promise to be high". The apprx. position and height of these peaks were not known until Brownlow got further rays from stations to the north in July and Aug. the following year [90, 226, 229, 493]. From Haramukh Montgomerie also got further rays to Nanga Parbat with a sketch [87]. In all he reported for 1856 position and heights for 36 snow peaks [87–8][5].

As with Mount Everest survrs. have been unable to find any name for K 2, but in this case the 'pro.' symbol has been retained on official maps. The unfortunate acceptance of the name Godwin-Austen by many is much to be deplored, for that redoubtable survr. had nothing to do with the discovery of the peak. He joined the survey as planetabler in 1857, and did not work in the Karakoram area till 1860, Montgomerie's son, Hastings Seton, protested against the name being used in this manner and writes to *The Field*, 27–8–1947; "My chief occupation of the moment seems to consist of 'debunking' the belief that Col. Godwin Austen either discovered K 2, or was the first to take an observation to it. ... The G-A myth is very tiresome. It was only started after my father was long dead, and before I was old enough to object [89–90, 95, 513]".

Godwin-Austen himself had no wish for his name to be used in this way [489].

From Haramukh Montgomerie moved on to Hant, 12,479, a peak above the road to the N. where he closed his obsns. for the season. After a last inspection of his planetablers he started the return march to Dehra.

"In addition to the professional work", writes Waugh, "Lieutenant Montgomerie had to carry on a great deal of correspondence, both with His Highness Maharajah Goolab Singh and the several native functionaries, as well as with this office and the various detachments. ... This added very much to...personal labours in the field"[6]. He was in fact in charge of two distinct operations—triangulation—topography—each with its separate staff [388–9].

Montgomerie was back in Srinagar in April 1857 with more officers and assts. to train, and with the added anxiety of the serious illness of the Maharaja

[1] now crossed by bridge on Pathānkot–Jammu rd. [2] DDn. 717 (27). Report on 1" map, TGM. to SG., 30–4–59. [3] DDn. 51 (12), to SG. [4] Sandes, II (199, n.2); letter from his son, H.S.M. 10–12–1926 to *The Field*, 27–12–1926, with Ed's. comments [5] *JASB* XXVI, 1857 (266–74) TGM. on heights of snow peaks. [6] DDn. 716 (84), SG. to Mil. Dept., 26–3–57.

who had been such a good friend to the survey. There was some talk of possible disturbances if he were to die, and there was some doubt as to the attitude his successor might take towards the survey. Montgomerie heard nothing of the mutiny until he received news from the SG. on 11th June [228], and decided to make no change in his plans except to call in Brownlow from the Kāgān to take over the main trgn. towards Skardo [493]. He thought it better to remain himself in Srinagar in close touch with the Māhārāja and his ministers. His knowledge of the country was indeed of considerable assce. to the Kashmir authorities in devising plans for dealing with a body of mutineers who tried to cross the borders from Peshāwar [482][1].

The Māhārāja died on 2nd Aug.; "On the 3rd his body was burnt according to the Hindoo custom. An earthquake took place at the time of his cremation." Lieut. Montgomerie went to the Shere Gurhi to show his willingness to do all honour to the deceased. ... Addressed an official letter of condolence to H.H. Māharāj Ranbeer Singh. ... On the 7th August...paid an official visit of condolence" [230].

Was greatly relieved to find Ranbir Singh was equally friendly towards the survey, and that the slight wave of hesitation shewn by officials was soon dispelled. "Business with the young Maharajah has been carried on in the most satisfactory manner".

One result of the disturbances down country was shortage of cash, and on 1st Sept., reports Montgomerie. "July's pay has not been received, and...it is understood that none will be issued till October. *Arrangements* have been made to meet the difficulties. ... Lieut. Montgomerie has to provide for all the officers, as well as his own party [485][1]".

Delhi fell to the British on 14th Sept.; In Srinagar "the eclipse of the sun was seen well on the morning of the 18th. ... A Royal Salute was fired on the 26th, ... and the Maharajah sent his compliments to Lieut. Montgomerie to let him know that it was in honour of the fall of Delhi, which he had just heard by express was entirely in our possession"[2] [485]. Montgomerie had for these last few months been the senior British officer in Kashmir.

In October he found time to sketch a magnificent coloured panorama of the Pīr Panjāl which stretches along the S. side of the valley. This was taken from a point on the S. slopes of Takht-i-Sulaimān, or Shankachariya. The original was 53 inches long, and coloured copies were printed in Calcutta between 1859 and 1861 [239; pl. 15]. Montgomerie acknowledges a final proof; "Many thanks for the complete proof of the Kashmir view. I think it is capitally done. I have shewn it to Mr. Simpson the artist[4], who has had a great deal to do with lithography; he seemed pleased with it. I should think one hundred copies...would be ample".

Survey of Kashmir and Jammu south of the main range was brought to a close during 1858 and the ½-inch map completed at Dehra by the end of April [231, 238, 319, 370].

During August 1858 there was an exceptionally severe flood on the Indus which reached *Attock* on night of *10/11th*, due apparently to bursting of some glacier dam in the higher reaches. A similar flood had occurred in June 1841[5].

After wide enquiries Montgomerie came to the conclusion that the origin of the flood was on the Gilgit R., probably in "Naggar, an independent district which the Maharaja's people called a part of Yaghistan, quite inaccessible to ordinary messengers. Nothing would induce a man to go there, and the Wazir said that when a present was offered the man took the money but only went a short distance and returned after a time with a made-up story. ...

"Beyond the fact that the flood had come from the Gilgit river, ... as shown by its carrying away the...gateway of the Nambal Fort, nothing positive was known as to the course of the flood, or the...site of the place dammed up, though the Boonjee sepoys believed it came from...Naggar. ...

"I feel quite certain that it did not come from above Skardo. ... Two of my assistants were working round Skardo, and another was working on the Shyok river within a month afterwards [232–3]. ... They heard nothing of a large flood from any of the inhabtants. ...

"Should the river Indus, or any of its tributaries be hereafter dammed up in any part of the Maharāja's territories, there would not be much difficulty in getting information. ... If, however, an obstruction should arise on the Gilgit River or any of its tributaries, there is in the present political state of those vallies no chance of getting timely warning"[6] [482].

During 1858 trgn. had been extended up the Indus into Ladākh and in 1859 start was made on a ½-inch planetable svy. [232]. After starting off various detts., Montgbmerie himself accd. Melville to make personal recce. of this distant and inhospitable country. Dropping Melville at Kargil he went on to inspect the trgtrs. and push on into the high land of Rupshu as far as the Tso Morari lake [141, 233–4].

During May 1860 he made astr. obsns. at two stations nr. Srinagar and found deflection of the plumbline with strong southerly trend [137 n.1 234]. He then left again for Ladākh, this time with Austen who had just rejoined from England, and was now bound for the Karakuram [235–6, 240]. In Aug., however, he had an urgent call back to Srinagar and spent the rest of the season at hdqrs. [234]. The Kashmir army now staged a successful attack on Gilgit which was captured with the loss of one man on each side. Montgomerie attended the Royal Durbar celebrating this triumph, and amongst the offerings presented was a magnificent bearded markhor. Lesser trophies were distributed to Montgomerie and other guests [481].

During 1861 he submitted a report on the svy. to Punjab Govt.—M 393, DDn. 53A [229 n.1]—with important papers on the Geography of Central Asia, the prospects of trade, and the possibility of geogl. exploration. He also submitted his map of *Kashmir Routes* [pl. 11], which he followed with a pamphlet giving precise details, which proved of great value and passed through several editions [238–9][7].

Earlier in the year he had accd. the SG. to Calcutta and remained during the hand-over by Waugh to Thuillier. He appears in a photo. group taken on the occasion, but like all other portraits available it is far from flattering [340 n.3, 417; pls. 20, 23]. He himself succd. to the post of Astr. Asst. vacated by Walker [380–1].

From 1861 his few adventurous survrs. extended trgn. and ½-inch sketch-svy. to the far borders of the Maharaja's territories, W. towards Gilgit, N. to the crest of the Karakoram, and E. to the frontiers with Tibet. The ½-inch map which covered the country south of the great range was completed at Dehra Dūn early in 1861, whilst the svys. to the north were pub. on the 8-mile scale in 1863 [239, 319, 330–1].

[1] DDn. 716 (156), Report for Aug. 1857; ib. (136), to Asst. Comnr. in Kashmir, 11-7-57, also 51 (35–6). [2] DDn. 716 (156), Report for Aug. 1857. [3] ib. (173), Report, Sept. 1857. [4] Wm. Simpson (1823–99), visited India from 1858; *DNB.*; DDn. 25 (167), 21-9-61. [5] *JASB.* x, 1841 (615–20, 677). [6] DDn. 717 (72), tgm. to Punjab Govt., 23-8-59; cf *HJ.*, 1 (10–29); paper by Mason. [7] later edns. compiled by Mason.

He now pressed forward proposals for exploration beyond the northern frontiers through the agency of trained Indian explorers, and during the next twelve years, supported by Henry Trotter, he not only directed the training and control of these devoted servants of geography, but disentangled and arranged their hard-won notes and sketches [380, 448–9][1].

7–11–64, reported that "the triangulation and topographical work of the survey of the Dominions of H.H. the Maharaja of Jummoo and Kashmir has been brought to a close as far as the field work is concerned, and as far as it is at present accessible to Europeans. We are now engaged in bringing up the computations, reports, etc[2]." [146–7, 237, 506].

20–2–65, suffering continuously "from low jungle fever", took furl. on mc. to England, having been continuously on svy. duty since 1852. He married, was honoured by the RGS. and rejoined 1–5–67, taking ch. of his old party, now emp. on Kumaun & Garhwāl topo. svy.; May 1868 to Jan. 1869, acted as Supt. Topo. Svys. in addition to his own duties during absence of SG., and again as full-time STS., 1870 to 1872. Took furl. on mc. early in 1873 and did not return [399, 491, 502, 508].

Writes to Walker from Portishead, Somerset, 7–5–73; "We have been down here for some time, and I think the place agrees with all of us. A strip of garden and a huge green field separate us from the shores of the Bristol Channel, so we have sea air and the country at the same time. My wife has got quite rested after the journey, and the two children are very flourishing; even I have picked up flesh".

Heaviside wrote a year later from Kew; "I saw Montgomerie at the R.E. dinner., ... still looking very ill, and I was sorry to see so little outward evidence of improvement".

Montgomerie again, 30–7–75, from Paris; "As to returning to India; I do not like the idea of leaving the service; on the other hand, it is a business to go out to India and to arrange about my family. ... Another question is, that, having got my health into good order, whether I had not better refrain from going into harness again; ... whether I had not better let well alone. ...

"If I came out at all, I should be inclined to join in November; I have rather a horror of the rains at Mussoorie, and I should not like to commence another tour in India with the rains, for practically there is no escape till October-November".

"I am over here looking after an exhibition of maps for a Geographical Conference. ... They asked me to represent Great Britain, and so I have been installed as Commissioner, and have my hands full of work. India and the G.T.S., are properly represented, and I think it will make the work better known. ... I brought you and vol. I [*GTS.*] prominently forward" [129].

Again, from Portishead, 9–9–75; "I have not quite done with the Paris Geographical Congress. I am only over here temporarily, having come originally to attend the British Association at Bristol, which is some 13 miles from this.

"The French Geodesists were really very enthusiastic about the Great Trigl. Survey of India. ... I showed them your vol. I, and the computations, levels, etc., and our Auxiliary Tables, and I understand they are going to give Hennessey what is the equivalent of an 'honorable mention' for having edited the last edition.

"They wanted to give but one lot of distinctions, to the G.T.S. only, but I said that would never do, as they had also got the Ordnance Survey before them, and eventually they awarded it one too. ... The Ordnance folk would have said I had merely been looking after Indian interests and had left them in the lurch. As it was, they were very jealous of an Indian officer, though an R.E., being made the British Commissioner. ...

"I was very much interested in the Russian section, and studied their maps as much as I could".

Walker was still pressing him to come out to act as SMS., but he writes finally, 1–10–75; "I was forced to telegraph to you that it could not be managed. ... I should have liked to have acted for you. ... I must see what my notions are at the end of another six months. I have settled the Paris Geographical Conference, ... and will...send you out the Letter of Distinction which they awarded to the GTS."[3]

He formally ret. in March 1876, having moved to Bath in 1875, where he died in Jan. 1878. His younger dau. d. in the same house, No. 66, Pulteney St., 24–12–1952; she had been a brilliant violinist whilst her elder sister was a skilled painter. Neither had married.

Preserved at GBO. Museum, item 15, Montgomerie's box of drawing insts., with lower drawer for scales and water-colours.

MULHERAN, James [IV, 384]. Civ. Asst. GTS. 5 ft. 8 in.
b., Wales, c. 1–5–17. unoov.
d., Seoni, C.P. 25–3–69.
Writer, SGO., 27–11–32; Sub-Asst. GTS., 19–4–34; Senr. 1st cl. SAS., Rs. 259–12, pm., 22–7–44; Senr. Civ. 2nd. Asst., GTS., @ Rs. 420 pm., 1–11–54; Surv., Rs. 600, 1–1–55 [419].

Son of Owen Mulheran who arrd. India c. Nov. 1833; bro. to Owen, of GTS. [IV, 375–6, 385; V, 419].

m., before 1847, Margaret Clarentine, their dau. being b. Allahābād, 23–3–47.

arrd. India c. 20–11–32; served Gt. Arc, 1834–6; Ranghir Him. Conng., Karara, & Gurwāni ser., 1836–47 [II n.3, 12 n.2, 361, 369, 403, 409]. With Du Vernet to NW. Him. Longl. 1847, doing exceptionally well on minor trgn. and plane-tabling in hills [422–3, 474]. SG. reports, 20–8–50; that he had "conspicuously distinguished himself by his zeal, activity, and ability in surveying the very difficult mountainous country between Kangra, Nidown, and Mundi. ... He is no less deserving of commendation for his uniform good conduct and kindness" towards the natives of the country by whom he is much respected and liked[4].

"None of the assts. of the party had any previous "practical acquaintance with the method of filling up the topographical detail of a mountainous country, a task of no ordinary difficulty in which few succeed. ... Mr. Mulheran was one of the first to master the system, and his surveys are conspicuous for their good quality as well as for the quantity of work achieved". He recdd. him for a personal allce. of Rs. 100 pm., of which Rs. 63–3–9 was sanctioned, bringing his pay up to Rs. 323 pm. [35, 36 n.4, 200 n.2, 416][5].

During summer months of 1851 rivalled Keelan in running remarkable ser. of minor trgn. into the hills. "17th March...commenced minor series east of Mandi, observing both sides of Beas; took triangles northward towards the Rotang Pass which was reached 13th June [by] station...15,124 ft. Series then followed Chandra River till junction with Bhaga, then north-east up the Bhaga, closing at Bara Lacha Pass at end of August [201–2, 286]. ...

"Started another series west across the watershed of the Chandra-Bhaga and Ravi, through main valley of Ravi, closing on principal triangulation south of Chamba. ... Fixed Sultanpur, Triloknath, Barmaur, Nurpur, Manikaru, and many snow peaks. Many...stations in Bhaga valley rose to 17,000 ft. [202, pl. 6]"[6].

His work was much appreciated by the Comnr. [204 n.3], who writes to SG., 21–5–51; "I have lately seen a good deal

[1] Markham (148–65, 428); *SI. Records*, VIII; *DNB*. [2] DDn. 51 (117). [3] Eur. Letters, II (14, 111–2). [4] DDn. 542 (37), to Mil. Dept. [5] ib. (225), 2–6–51; 606 (119), Mulheran to SG., 25–10–51. [6] *GTS. Syn.*, VII (lvii—C)., cf. *AJ.* LXI, 293 Nov. 1956 (279–93) with map.

Mr. Mulheran in Kulu, and have been very much gratified with what I have seen, both of his work and himself, as the information...obtained from him [426].

"He is just the kind of person for these wilds, sensible, and conciliatory, and getting on admirably with the people. ... You certainly deserve infinite commendation... more particularly for the introduction of the planetable and the admirable topographical surveys thus secured.

"Notwithstanding...the extreme difficulty of triangulation in such a country, Mr. Mulheran seems in no way daunted, and is getting on apparently to admiration. ... I trust we shall have no difficulty in getting 2 staves placed for him on visible points at the summit of the range"[1].

The high Himālaya is a hard country—villages are few and far between—supplies have all to be imported. Mulheran found it difficult to keep his men at work; "I am now sketching the ground between the Bara Lacha—Kalzam pass—Rupshu...and Zanskar [205 n.5]. The Chandra and Bhaga rivers have their sources near the Bara Lacha, and both have been sketched from their sources to their junction under Tandi. ...

"I have now been 15 days away from a village and have about 15 maunds of atta remaining to subsist myself and people while...sketching the ground north of the Bara Lacha bounding Lahaol from Rupshu. I arrived late this evening near the Spiti or Kulzum Pass but, having lost sight of my points, ... have been unable to do anything. Tomorrow I intend proceeding to a hill about 16,000 feet above the sea, from which I am in hopes of being able to...sketch what remains to fill my board. ...

"All my men are worn out, and...it is with the greatest difficulty I...make an ordinary march. ... All would no doubt leave me tomorrow were they certain of their arrears"[2].

During 1852 he extended trgn. and detail svy. E. into Chamba. He started at end of April at Dala N., north of Pathānkot, and brought his trgn. N. to the Sachi Pass "on the great snowy range dividing Chamba proper from Pangi, the Chattardhar Range", the higher summits being from 17,000 to 18,000 ft. It was rough going and Mulheran had a nasty fall, "the shock of which was so great as to deprive me for a time of sense and motion [204–6].

"A few days subsequently I suffered distressingly from being obliged by unfavourable weather to remain a night upon the summit of Sachi snowy cone, and...a visit to the station above Sachi was followed by shifting pains across the shoulders and along the spine, which...led me to entertain doubts of being able to finish. ... Though much better...I am far from well. I am, however, steadily progressing and hope in...another month to finish the whole of Pangai and a considerable portion of Chamba Lahaul" [pl. 11][3].

He successfully completed the svy. and, marching back via Mandi and Bilāspur, reached Dehra Dūn on 25th Oct., having survd. nearly 3,000 sq. m. on the ½-inch scale during the season, besides about 1,000 miles of trgn. [205–6].

1–1–53, took over ch. of the party after Du Vernet's tr. to Assam [20, 361, 423] spending summer in high ground from which the three great rivers, Sutlej, Jumna, and Ganges have their sources. With Shelverton and Dyer he tried without success to link up the trgn. across the great range.

Working from the south he was himself defeated by heavy snow round the Nela Pass. "The impossibility of approaching any of the passes leading into Tartary or of occupying points sufficiently elevated to command a view...subsequent to the heavy falls of snow in October induced me to lose no time in proceeding...to...the measurement of the Chuch base-line. ... I accordingly marched from Derali near Gungotri on the 20th October, and proceeded via Dehra, Ropar, and Hoshiarpur to Adinanagar, at which place I was joined by Messrs. Shelverton and Dyer from Kanawar" [III, 40][4].

Feb. 1854, after asstg. in meast. of Chach base-line, asstd. Strange to measure width of Indus below Attock in search for site for suspension bridge [43, 208, 532][5]. He then returned to the head of the Sutlej valley and pushed the svy. as far east as possible, whilst Johnson made the connection to the south [208], bringing operations of Him. topo. party to successful end [207–8].

Mulheran had done so well on the Himālaya svy. that SG. now selected him to restart Hyderābād svy. that had been suspended in 1850 [178], and he was appd. survr. in ch. from 1–1–55, on salary Rs. 600 pm. [4, 384, 403]. He did remarkably well, worked harmoniously with State officials and, owing to difficulty of finding European or Anglo-Indian assts. recruited and trained a number of Indians with excellent results [178–9, 268, 416, 426, 447, 485].

"Mr. Mulheran has also perfected himself in photography and is now employing that art in copying and reducing his maps. He is also preparing an interesting report on the country with photographic illustrations [142][6]".

His photography had excited the interest of the GG., and the SE. writes to Govt. in 1858; "I have just received from Mr. James Mulheran...who is a most expert photographer, five exquisite specimens of his work to be presented to Lord Canning as samples of a large collection which he is making for the Governor General. ... If there are any particular people or places in the Deccan within a moderate distance of his work of which Lord Canning may require photographs, he will gladly furnish them.

"The specimens...are a single portrait of Janojee Bhonslam commonly called the young Raja of Nagpoor—a group with Janojee and five of his friends and attendants—a pavilion in the Maharajbagh at Seetabuldee—and two views of Jain temples at a waterfall...in the Baitool District'".

1861, allowed cost of chemicals and materials at Govt. expense for photos. of people of CP. and sent in 20 copies each of various groups, "executed in a masterly style"[8].

Marwarees, or cotton merchants of Berar—Koombees, or cultivators—Lingaith banias, and ordinary banias—Gosains, two groups—Rohillas—Gonds, Kalwas, and Komars of Berar.

Policemen—Kosars, or braziers—Wadaries, or navvies—Korku trackers of the Satpura Range—Tailies, or oilmen—Gypsies—Brahmins and Purboos of Comnr's. Courtant of DC.'s court, Amraoti—Rahkwar Rajpoots of Fort Gawilgarh—Ratore Rajpoots of Amraoti.

Bairagies—Gaulies—Ranwar Fakir—Lohars, or iron smiths—Dallals, or cotton brokers—Raingi, or travelling cart[9].

He writes to a friend at Calcutta who had sent a print of the svy. group taken on Waugh's departure [340 n.3, 515; pl. 21]; "My dear Will, ... The photograph, ... would have been first-rate had all the sitters been steady during the exposure. The only real good likeness in the group is Maj. Walker, next Sir Andrew and the Colonel [Thuillier]. That of Captn. Montgomerie I do not at all recognize, and I wish I had been present when the plate was being developed, as I could have satisfied Mr. Rowe[10] of the advisability of taking a second. The lense of the camera used must be a first-rate one, and I wish I had one like it. Kindly thank the Colonel for his kindness in permitting me to have a print.

[1] DDn. 607 (47). [2] ib. (50), to SG., 6–8–51. [3] DDn. 606 (142), to SG., Padaban HS., 24–7–52. [4] DDn. 549 (159), Report, 1853–4; 609 (90), to SG., 28–10–53; (95), 19–11–53; ib. (177), to SG., 11–11–54. [5] ib. (119) Mulheran to SG., 5–4–54. [6] DDn. 652 (5), to Mil. Dept., 6–10–60. [7] DDn. 655 (127), Alex. Boileau to Govt., 1–12–58. [8] BMC., 7–1–62; DDn. 21 (222), SG. to 1–8–62. [9] DDn. 44 (156, 170), Mulheran to SG., 21–6 & 21–7–62. [10] possibly kin to Josiah Rowe [III, 448; IV, 457 n.8].

"I have been dangerously ill, but I am now...all right, again; at least, altho' my stomach is still a little wrong I am able to digest what I eat and to sleep at nights. The doctor here will allow me to return to my duty tomorrow"[1].

By season 1865-6 he had taken his party—now No. 2 Topo. Party, CP. svy.—N. through the CP. jungles drained by the Wardha and Godāvari. He had an uncomfortable elephant ride; "While moving over...Chankari plateau with the boundary commissioners the branch of a tree swept Capt. Farrell and myself off the back of the elephant, severely injuring my side and back, and intensifying for a considerable period the ordinary difficulty...in breathing while ascending hills"[2].

At last, like many another valiant survr., he gave his life for the work. He left Ellichpur on 30-11-68, but was worried by an obstinate malarious fever, and was held up for three days on Hati HS. under care of the Indian doctor. "Not getting better, he crossed the Wardha R., and went up to the Mooltye plateau; ... resumed observing...on Dec. 21st. Although in a very enfeebled state he carried on for some time...in the notoriously unhealthy tract called Khamarpani, but was again prostrated at Bichua village...on 6th Feb., and had to go into Chindwara station for medical treatment.

"Having halted there for a week only, he—against the advice of the Civil Surgeon— ... again resumed observing on Banadai HS. near Seonee on the 22nd February. ... He had... worked for five days when he was again taken ill, and marched into Seonee station in a very bad state on the 28th Feb. ... He rapidly got worse and succumbed...on the night of 26th March. His wife had been sent for and arrived from Ellich the previous evening, but only to find her husband in an unconscious and dying state" [416, 428][3].

MURRAY, William George. Ben. Inf. & SC.

b. 10-3-35. d. 18-5-94.

Ens. 9-6-55 ... Lieut. SC., 18-2-61; Lt Col. 23-9-71; 2 y. furl. 6-2-73; hpl. 14-2-76; ret. 1-7-82.

Son of Capt. Wm. Murray (1801-42), Ben. Inf., Hodson, III (365), and Sophia Ann, dau. of Rev. Jas. Lynn, vicar of Keswick.

m., Mussoorie, 2-1-60, Florence Isabella, dau. of late Capt. J. D. Young, bde. maj. Queen's Troops, Ft. Wm.

IO., *Ben Services* vol. II; *India Regrs.*, 1877-95.

12-4-57, appd. Topo. Asst. on probation, Kashmir svy., joining Srinagar 21-5-57, and made permt., 22-2-58 [227, 231, 389]. After instn. by Montgomerie survd. 1st. planetable across Wular Lake N. to Trāgbal; 2nd. on highest Pir Panjāl; and 3rd. round Kishtwār in Chenāb valley. During 1858 survd. in w. Pūnch, towards Murree [229-31, 512]. Finding mountain climbing "uncongenial", he was tr. in Sept. 1858 to the Rāwalpindi party, which he accd. in 1859 to Gwalior [190, 213].

Robinson was doubtful about his fitness for independent ch. in 1861; "I have great confidence in Lieutenant Murray's abilities. ... At the same time...[his] experience lies principally in the office work of the survey. Circumstances have precluded his having more than two and half months practice in plane-tabling on our system, and about the same amount... in triangulating. ... I trust that, should a party be placed under his charge during the coming field season, due allowance will be made for any shortcoming."[4].

The SG. was optimistic; "I trust that the insight which Lt. Murray must have gained into the working of the Department...will fully qualify him for conducting independent operations. .. If an officer is not fit for this after 4 years... he must be out of place altogether"[5].

Murray was therefore given ch. from 1-7-62 of a new. topo. party, No. 5, raised for work in Rewah, an appt. that at once roused protests from Austen and Melville, who were both his senior in army rank and in posting to the Kashmir Svy., they both had to wait another 3 years before drawing full ch. allces., Rs. 618 [389-90, 400, 489].

Finding that the climate of Mussoorie did not suit him, Murray made recess qrs. at Chunār on the Jumna. He took furl. in 1866 and rejoined, 24-3-69, to hold ch. Photo-litho office at Calcutta.

April 1872, accd. Alex. Cunningham on archaeol. tour Upper India taking photos which won silver medal at Calcutta exbn. Rejoined SOO. 21-10-72, but ill-health compelled 2 y. furl. under GO. of 5-2-73. Did not rejoin.

NASMYTH, David Jobson. Bo. Engrs.

b. 9-3-29.

d., Adelaide, S. Australia, 30-9-71.

2/Lt. 10-12-47 ... Lt.-Col. 17-6-68; ret. 20-9-71.

Son of Robert Nasmyth, FRCS., of Edinburgh, surg. dentist to the Queen, and Mary Lockhart his wife.

FRGS. 1859; Conolly (107/134).

GO. GG. 14-11-51, appd. 2nd. Asst. GTS.; DO 29-11-51, to Bo. trgn. under Rivers, joining 29-12-51 with ch. March 1853; 1st Asst. GTS. 24-3-54 [54, 380, 523] Asstd. at meast. Karāchi base-line Nov. 1854 to Jan. 1855 [44].

1853-9, in ch. trgn. Kāthiāwār and Cutch [3, 157, 338, 470, 472-3]; failed to find suitable site for tide-gauge; health suffered constantly from operations across Rann of Cutch; "The exposure I had had, ... and want of food— ... without tent, baggage, or servants—together with very bad water—induced an attack of acute dysentery from which I have only now recovered [57-9, 73-4, 367].

"Many of the establishment and servants have been variously affected—and Mr. McGill has not escaped—the deleterious effects of the water which is, I presume, the cause of the most of our sickness". ...

Six weeks later; "The weather had become unfavourable for observation, for the dry dust on the surface of the Runn and its neighbourhood was raised in clouds by light winds, and when disturbed by a strong breeze it did not subside for days. ... Having completed the observations at Khanmir—for the dust did not make way freely over the hilly country to the north of Monabu[6]—I had set up the instrument at Kaismara, a bleak island...on the Runn, but I saw no prospect of taking the observations satisfactorily, and as I was still under the effects of my late illness, ... I could not contemplate another profitless month of April. ... I determined therefore to postpone further operations for the present.

"I took our supply of water for Kaismara from Khanmir, about a distance of 14 miles for, though I had water brought also from the Kathiwar coast, it was hardly palatable enough for drinking, while the distance it was brought was only two or three miles less"[7] [60, 65].

1857, after taking over ch. of various public offices at Bhūj in support of the civil power, he answered a call for engr. help and hastened to Deesa in Rājputāna, but, arriving there on 14th Oct., was too late to acc. the mil. column advancing into Jodhpur, and returned to his svy. party[8] [141].

Oct. 1859, obtained SG.'s somewhat tardy consent to accept call from Bo. Govt. for him and Haig, his newly joined asst., to join Okhamandal fd. force, where Nasmyth comdd. the engrs. at siege and capture of Dwarka fort from the "Vagher" insurgents[9] [500].

10-3-60, handed over to Haig, and sailed, 27th from Bombay on furl., the SG. commending his services; "He has distinguished himself by his zeal, judgement, and indefatigable activity. His abilities are of a high order and, ... he

[1] DDn. 44 (105), Chāndna, 28-1-62. [2] *GR Topo. 1865-6* (appx., xxiii); 21-8-56. [3] *GR Topo., 1868-9* (41). [4] DDn. 714 (241), to SG., 16-7-61. [5] DDn. 687 (61), 30-7-61. [6] SE. Cutch, on Little Runn. [7] DDn. 720 (114, 121), 29-2-& 12-4-56. [8] *GTS.* XIV & *Syn.*, XXXIII (viii—L); *Bo. Prov. Gaz.*, VIII (595-7). [9] MRIO. Misc. D-6; plan of town & fort of Dwarka.

has earned my entire confidence. ... I trust...that on his return to India he may be reappointed" [382].

Furl. extended to 4¼ y.; returned June 1864, to assume ch. Bombay svy. "After about a year...again went to Europe on furlough, this time for 2 years, of which, however, he only availed himself of 9 months. On his return he... served for about 6 months, and then went to Australia on leave...for 2 years under MC."

The question of his seniority in the Dept. after return in 1867 was referred to Govt. who placed him below Basevi who, though 4¼ y. his junior, had actually served longer in the Dept., and when he returned once more in 1869 he found himself superseded by Hennessey. The SG. could not support his protest;

"Nasmyth is one of the pleasantest and most popular of men, a kind friend, and almost universal favourite, but it is his misfortune, partly from bad health, partly from other causes, to have been dissociated from the operations of this Department for no less than 7 years out of the 10¼ years which have elapsed since he first went home on furlough in 1860"[1].

1870, again took sick leave to Australia, and d. there shortly after.

NICOLSON, James O(u)chterlony [IV, 385].
Civ. Asst. GTS.; uncov.
b., India, *c.*, 1–3–19.
d., Upper Norwood, England, 25–1–69.

Writer, SGO., Oct. 1835; SAS. 3rd. cl., GTS., 1–9–36 ... senr. 1st. cl. Asst. @ Rs. 259–12–3, 31–3–45 ... Civ. 2nd. Asst. GTS. @ Rs. 400, 1–11–54; ret. on pension June 1866, under GO., 21–12–65.

Son of Capt. James Nicolson (1788–1835), Ben. Inf., Hodson, III (393), inv. 1832, who m., Karnāl, 20–4–18, Louisa, dau. of Lt.-Col. E. W. Butler (d. 1819), Ben. Art.; to England and back as a child, to live in Simla whilst father served with 1st Nassiri Batt., Sabāthu & Kotgarh [III, 40 n.5].

1836–40, Gt. Arc; 1841–50, Him. connq. and Calcutta merdl. ser. [14 n.5]; Feb. 1845, deputed to svy. Hooghly R. for nvgn. purposes; minor trgn. with 12″ theodolite and topo. sketching; svy. from Nadia junction 12 m. s. of Krishnagar to Kaukhāli lighthouse, completed May 1848 [15].

Directed to leave "nothing to conjecture, ... laying down all the marine marks, etc., as well as creeks and tributary rivers. If...careful to sketch in the country...so as to represent its cultivation, groves, forests, extent of inhabited sites and other topographical data, we shall be able to project his work on a large scale and have it published, ... which... cannot fail to give public satisfaction and place Mr. Nicolson's name in the highest rank of surveyors. Extreme accuracy and completeness are the grand objects"[2].

Though Nicolson was no sailor and had a very rough time, his final work was pronounced "entirely creditable".

Season 1848–9, with Peyton to Tirhut section of NE. Longl., and emp. on minor trgn. to provide points for rev. survrs. [19, 296–7].

1849–50, took over ch. with special task of completing obsns. to snow peaks which Peyton could not combine with trgn.; working E. through Tirhut and Purnea from Nov. 1849 to Jan. 1850, he was remarkably successful, and his "sharp peak (*h*)", obsd. from 6 stations was eventually computed as Pk. XV, with height 29,002 [85, 91–3, 96, 520].

1850–2, completed N. Parasnāth ser. [15–6, 288, 361, 394], and then started Assam longl. handing over to Du Vernet Jan. 1853. Took over ch. again on Du Vernet's resgn., and brought ser. to Goālpāra by end of 1856, with all his assts. and himself broken with malaria. Relieved by Lane in Jan. 1857, took furl. to England [2, 5–6, 19, 29–31, 85–6, 100, 132, 155, 345, 369, 373, 403, 454, 468].

The MC. granted in Darjeeling, Aug. 1856, describes him as typical case of long service in jungle areas; "He is of temperate habits; is stout, and has the appearance of a man who has been long resident in a tropical climate. He has had five severe attacks of fever; 1st, intermittent fever contracted in the Dhoon in 1842 [461]. ... 5th., a remittent fever caught in Assam on 16th April last. ...

"He has now partially recovered his strength, and suffers very much from nervousness and low spirits, ... vertigo, and loss of memory. He is unable to apply himself to study, and finds it totally impossible to make the calculations... necessary in his work. He has taken more or less mercury during each attack of fever, consequently...there is a scorbutic tendency in the system"[3] [415].

DO., 8–9–58, on return from furl., posted to No. 2 Orissa topo. svy. taking ch. from Depree 28–12–58; remained with party after Depree's return in 1860, and much distressed at not receiving another ch. [174–6, 387, 408].

1861–3, to ch. No. 1 Astr. Party, fixing positions of Port Blair, Cocos and Preparis Is. to north.

1863–6, emp. in ch. Waste Lands svys., Lower Assam and Cooch Behār, and tempy. ch. Khāsi Hills topo. svy.; closed work June 1866—final report 4th June—and ret. on pension sanctioned 21–12–65, "with broken health, reduced by the hardships of a fever-stricken tract"[4].

OAKES, Richard Edward. Ben. Inf. & sc.
b. 21–2–29. d. 22–10–91.

Ens. 11–12–47 ... Lt.-Col. 11–12–73; ret. as Col. 1–8–77.

Son of Lt.-Col. Oakes, E. Dereham, Norfolk.

Dec. 1853, on Pegu Svy. [195–6].

8–4–58, appd. Asst. Rev. Survr. and posted to Donald Vanrenen's party at Nāgpur, taking over ch. 8–2–59; moved party to Jubbulpore 20–11–60 [263, 396, 400].

Continued in ch. OF. rev. svys. Chhindwara, Betul, Raipur, with furl. 1862–4; 1870–2, till tr. 1874 to cadl. svy. Shāhābād; 1875–6, in ch. W. Son irrigation svy.; 1876, furl. pending ret.

OUCHTERLONY, John.[5] Mad. Engrs.
b. 1813; bapt. 15–4–13.
d., Ootacamund, 22(29?)–4–63.

2/Lt. 14–6–32 ... Lt.-Col. 18–2–61.

Son of Wm. Ouchterlony, merch., trading with Russia, and his wife Henrietta Charlotte Row; bro. to James Ouchterlony, MCS., at one time Judge at Ootacamund.

m., Colombo 6–4–44, Alice Trevor, dau. of Sir Thos. Edw. Turton, 2nd Bart.; she d., Winchester, 6–5–1915, aged 87.

Conolly (100/161). Oriental scholar and intpr. in Tamil; auth. of *The Chinese War*, London, 1844, written as actg. engr. "at the new settlement of Hongkong"; Described by *Cal. Rev.*, I (152–88), as "the work of a highly intelligent and candid mind, feeling sensibly the irksomeness of official restraint, but compelled to submit to it".

17–7–35, appd. asst. on construction of anicuts [I: 95 n.6]; 1840–2, with expn. to China [IV, 260].

MGO. 28–3–44, appd. to ch. rev. svy. in Nilgiri Hills [8, 179–80, 400]. Obtained instns. from SG. regarding svy. methods which were found too elaborate for the simple work required [281–2, 285, 297].

After completing rev. svy. scale 1000 ft. to inch with memoir for Rev. Dept., extended topo. svy. with ½-inch reduction for SG. [279, 290, 363, 421]. At end of 1852, reverted to engr. duties, and much to SG.'s regret the svy. was closed down [383–4].

[1] DDn. 7 (243–6), SG. to Mil. Dept., 27–10–60. [2] DDn. 515 (83), SG. to Peyton 27–2–45. [3] DDn. 703 (56), from Civ. Asst. Surg., 30–8–56. [4] *GR. Rev. LP. 1864–5*, Vanrenen, 11–12–66. [5] not James as in J. J. Cotton (281/1607).

PEMBERTON, James Jeremiah [IV, 460].
Civ. Rev. Survr., unoov.
b., England or Ireland, 1801/2.
d., Darjeeling, 21–4–60, aged 58.

Sub-Asst. Rev. Survr. @ Rs. 50, 1–6–35; Asst. Rev. Survr., @ Rs. 250, 1–6–38; Rev. Survr., @ Rs. 526, 1–10–48,

Son of clergyman; claimed by Henry Lawrence [IV. 452–4] as school-fellow, possibly private sch. at Clifton.

Portrait from SGO. colln., [pl. 25].

m., Allahābād, 16–10–38, Arabella Eliza, wid. of Daniel Permien, sch. mr.; a son, H. L., was appd. sub-asst. rev. survr., 20–12–56; another son, James Stuart, b. 8–6–43, pr., Patna, joined Rev. Svy. 6–10–60, and m., Allbd. 24-12-80, Gert. Margaret Genevieve, dau. of Thos. Willes, of Allbd.

arrd. India 1823, having enlisted in 60th Ft. 23–6–23; tr. as corpl. to 2nd Ft. (Queen's) 18–1–25, but reduced to pr. in July.

1–6–35, joined rev. svy. Farrukhabad under Lawrence, taking furl. from regt. at Bombay; 30–6–36 purchased disch. for £10 [IV, 390, 460; V, 442][1].

1–7–45, from asst. with Bhāgalpur rev. svy., relieved Fitzpatrick in ch. Purnea rev. svy.; retained this ch. till death, moving in succession to Mālda, Rājshāhi, Pābna, Rangpur, Dinājpur [6, 241–6, 253, 296, 299, 313, 433–4, 452, 455].

A capable rev. survr., whose party maintained excellent record of good work, the only occasion of his meeting Govt. disapproval being when a boatload of Govt. property, incl. svy. records, tents, and insts., was lost in storm on river between "Commercolly and the Dewangunje Thannah. ... Mr. Pemberton was deserving of censure for a direct infringement of rule of the Department which enforces the adoption of land carriage whenever practicable"[2] [372].

Three mo. after his death his wife wrote from 27 Devonshire Place, London.

PEYTON, John [III, 494–5; IV, 460–1].
Ch. Civ. Asst., GTS.; uncov.
b., India, c. 3–6–04.

Sub-Asst., GTS., 1–10–23 ... Dep. Compr., 18–1–32 ... Ch. Civ. Asst., @ Rs. 600 p.m., 18–5–49; ret. 10–4–56.

Son of Wynne Peyton, Supt. Surg. Mad. Med.; uncle to James Peyton, appd. sub-asst. Hdbd. topo. svy., 1–8–47 [414, 428, 432].

1833–43, with Gt. Arc and SG.'s fd. hdqrs. [81]; Sept. 1843, with SG. to Calcutta; 19–10–44, assumed ch. Calcutta Merdl. ser., and after closing nr. Sonakhoda base, marched party to recess at Benares, 7–7–48 [15, 126, 131, 361]. Rewarded by promotion to Ch. Civ. Asst. to fill vacancy caused by ret. of Joseph Olliver in 1842 [345, 402, 510].

1848–9, emp. party on section of NE. Longl. ser., between Chendwar and Maluncha ser. through Bhāgalpur and Purnea dists., but unable to get obsns. to snow peaks that were carried out by Nicolson the following season [17, 19, 82, 84–5, 155, 369, 519].

Oct. 1849, tr. to Dehra Dūn to work on GTS. comps. [343]; 1850–1, with Renny revised w. section of NE. Longl., conng. Gt. Arc with Ranghir ser. [16, 21, 86, 90, 92, 460, 523].

Jan. 1852, assumed ch. E. Coast ser. at Cuttack [26–7, 71, 73, 109, 127, 153, 367, 373, 453, 465] handing over to Strange 10–4–56, to ret. on full pension Rs. 300 pm. which for service less then 35 y. required cert. from Med. Bd.

The Bd. at Cuttack declared him to be "permanently disqualified from impaired vision, and a general break-up of constitution". He himself referred to "repeated attacks of fever in its worst forms—pulmonic attack...from which I long suffered...—nor have I even escaped the ferocity of wild beasts, having been left for dead on one occasion by a panther which suddenly sprung on me and struck me down [15]—the effects of all which are too apparent in the enfeebled and emaciated body and, added to the continued strain on the eyes by the use of powerful glasses and microscopes...my sight has also been materially injured and weakened"[3].

In farewell order SG. acknowledged "his long, faithful, and valuable professional services, as well as his honourable conduct, upright principles, and amiable social characteristics [414–6, 420]"[4]. Painted Waugh's portrait [541].

His value to the Dept. had been the greater since he had been brought up by Everest in the highest standards of geodetic precision both as obsvr. and compr. [10, 394].

After ret. lived for a few months in Dehra Dūn before leaving to settle in England.

PRATT, John Henry. Archdeacon, Calcutta.
b. 1808/9. d., Ghāzipur, 28–12–71, in 63rd. y.
MI. in old Missy. Ch. & Cath. Calcutta.

Asst. Chpn., EIC., 19–1–39 ... Achdn. 6–10–49.

Son of Rev. Josiah Pratt, Sec. of CMS., London; vicar of St. Stephen's.

ed. Oakham, under Dr. Doncaster; adm., 1829, aged 20, Gonville & Caius Coll. Cambridge; 3rd Wrangler.

m., Bhāgalpur, 6–3–50, Hannah Maria, dau. of Geo. Francis Brown, BOS.; she d. 28-11-1915.

MA. 1836; FRS.; mathn.; auth. of papers on geodetic and geophysical subjects, 1855–66, pub. in *Phil. Trans.*; *RS. Progs.*; *Phil. Mag.*: *Mathl. Prcples. of Mechl. Philosophy.*

Markham (140); *DNB.*; *DIB.*; *ASB. Progs.*, 1855 (88–9); 1865 (88) 1872 (22) *JASB.* XXVII (201–13); XXVIII (22–7, 310–6); XXIX (266–74; XXXI (646); XXXIV, II (34); ASB. *Index*, 1884; Blunt (200–1/805); Evan Cotton (638); *Times* 2 & 29–1–72; *Nature*, 8–2–72 (291); Larousse; *Al. Cantab.*; Stokes' Sch. Regr. (1); portrait, GBO. Museum.

arrd. India, 1838; later, Chpn. St. Paul's Cath., Calcutta.

1853, during visit to Mussoorie on diocesan duty was consulted by SG. on subject of Him. Attraction, and taken to summit of Banog. Became greatly interested and, being gifted mathn. and imaginative thinker, made notable contribution to this branch of geodesy [93, 136–7, 530, 541].

Made calculations of probable attraction from known orography of Himālaya; had long corr. with Waugh, Tennant, Airy, and others. Wrote to Waugh, 4–2–56, from Lausanne, ref. "paper lately printed in the *Phil. Trans.* on Himalayan Attraction about which I wrote to you...in Sept. 1853, from the Cape of Good Hope. ... I hope to forward a copy of a second paper...together with some observations on a paper of Mr. Airy. ...

"As the subject is of importance, I am anxious to pursue it... as long as my holiday lasts, which is till the end of this year, as I hope to be back in Calcutta in November next. ... I am anxious to have your opinion...whether I have assigned a reasonable height to the masses into which the Himalayas are supposed to be cut. ... I enclose a diagram". Hennessey suggested that he should consult the atlas sheets lying with John Walker in London[5].

Writes to Tennant, who had disputed some of his deductions, telling of discussions with John Boileau [IV, 422–3]; "Mr. Airy has been surprised at the large amount of deflexion

[1] PBO.; P & M. Rolls, 2nd Ft., WO. 12 (2032, 2043); Disch. Regr. WO. 25 (3245); disch. cert. shewing birth etc., destroyed by fire. [2] BBC., 11–10–55 (17–20). [3] DDn. 687 (44), to SG., 7–9–55. [4] DO., 10–4–56; DDn. 578 (15). [5] DDn. 32 (31–3), to SG.

in India. He does not call in question the correctness of my results, ... but he suggests that another cause may be in operation, viz., a deficiency of matter below the mountain masses which would have a contrary effect on the plumbline. ...

"There are two unknown quantities in the problem of the figure of the earth determined geodetically. ... 1st. The deflection...owing to local attraction. 2nd. The deviation —of the form of the surface which may be under examination— from the spheroidal"[1].

Pratt's major contribution to the subject was that the deflection calculated from the known distribution of mountain mass was much greater than that actually observed, from which he deduced the theory of Isostasy associated with his name [136–7].

PRATT, Robt. Torrens. HM. 84th & 69th Ft.
b., Meerut 7–10–34. d., Ireland, 2–8–67.
Ens. 84th Ft., 11–6–52 ... Capt. 84th Ft., 24–8–58; to 69th Ft., 11–11–58.
Son of Lt.-Col. T. S. Pratt HM. 26th Ft. OB., & Ann his wife.
1857–8, at relief & capture of Lucknow.
1858, appd. Dep. Supt. 2nd cl., Madras Svy.; Kistna & Masulipatam 1858–61 [280, 401].

PRESCOTT, Cyril Jackson. Bo. Inf. & sc.
bapt. 31–8–24. d. 2–9–93.
Ens. 17–1–46 ... Lt.-Col. 17–1–72; ret. 1–4–76.
Son of Rev. John Prescott, vicar of North Somercotes, Lincs., and Eliza his wife, dau. of Thos. Philips, of Louth.
m., 6–5–45, Harriet Ann, dau. of Comdr. G. Tupman. RN.
11–9–50, appd. Asst. Rev. Survr., Ahmednagar 29–9–55, Dep. Supt.; 26–9–59, Supt. Gujarāt Rev. Svy.; furl. 1860–2 and 1870–1 [398, 401]. *IO Cat.* (422), memo. on Rev. Svy. N. DIV. Bo. Presdcy. 1873.

PRIESTLEY, Fredrick John Blakiston.
HM. 74th Highlanders & Mad. sc.
b. 29–8–19. d., Bath, 17–1–94.
Ens. 82nd Ft., 2–3–38; to 25th Ft., May 1838 to ½-pay as Capt., 21–5–53; Capt., 74th Ft., 23–7–54; ... Maj. MSO. 18–2–60...Bt. Col. 2–3–69; ret. July 1876.
b. at Burghfield Ho. pr. co. Berks; pr. kin to Maj. Edw. Jonathan Priestley, not in regt. army, RH., DIG. Constabulary, Dublin Castle, who witnessed his marriage.
m., Ennis, Co. Clare, 6–4–52, Amelia Priestley, dau. of Mr. J. Millar; a son, Fred. Joseph Blakiston, was b., Ootacamund, 18–4–58, and comnd. in HM. 17th Ft.
Ed. RMC., Sandhurst. Boase; *Times*, 20–1–94.
22–2–53, appd. to rev. SVY. S. Arcot Dist.; 18–8–57, 1st. Supt. Mad. Rev. Svy., holding post till ret. from SVY. 1876 [8, 279–80, 401, 411, 503].

RADHANATH SICKDHAR [IV, 461–2].
Chief Computer.
b. Oct. 1813, Sikdarpara, Jorasanko, Calcutta.
d. 17–5–70, Gondalpara, dist. Hooghly.

Compr., SGO., 20–12–31; SAS., GTS., 3rd. cl., 7–5–32...2nd. Prcpl. SAS. @ Rs. 350 pm., 22–7–44; Ch. Compr., 31–3–45; ret. 15–3–62 [IV, 339, 371; V, 344, 356, 420, 449].
Son of Titu Ram Sikdar, Brahman, and elder bro. to Srinath, appd. compr. 25–1–38 [341, 356, 360]. Kedarnath, son of Srinath, d. Nov. 1936, leaving a g.son, Satyen N. Mukerji, attorney of High Court, Calcutta.
Portrait [pl. 27] from original in oils with the family.
ed. 1st, at sch. of "Feringhee" Kamal Bose at 48 Chitpore Rd.; adm., 1824, to Hindu Coll., rising to 1st cl. by 1832.
FRAS. 1853.
Biog. notes by Jogesh Chandra Bagal, *Modern Rev.* 1933, April (457–60); Sept. (291–2); *Prabasi*, Aug.–Sept., 1932; *Desh.*, IV, Nov. 1936; (Calcutta periodicals).
Auth. of, or contributor to, several deptl. technical pubns.
Oct. 1832 to July 1833, with Waugh & Renny on march via Amarkantak to Gt. Arc through Gwalior [IV, 270–1]. From 1833 with SG.'s fd. hdqrs. Gt. Arc and Hāthipaon, on comps. and fd. work [446]; Oct. 1843 with Everest by boat to Calcutta; Oct. 1844 with Waugh to Allahābād in ch. fd. comps. [341, 402].
On De Penning's death March 1845, succ. as Ch. Compr., remaining with fd. hdqrs.; from Oct. 1846, with fd. hdqrs. to Dinapore holding ch. during SG.'s absence in Darjeeling with Regtr. One month's leave to Calcutta reporting to DSG. 12th July 1847 [127, 341].
2–9–47, on receipt of orders to surrender ch. of fd. office to Webb, Regtr., submitted resgn., but withdrew this on Waugh's remonstrance of 8–2–48. Dec. 1847, moved with fd. office from Digha Ghāt to Dehra Dūn, a 4 mo. journey [341].
At end of 1848, SG. decided to concentrate compg. section at Calcutta; Radhanath and 4 comprs. left Dehra at end of Jan. 1849 and reached Calcutta by boat on 2nd May. Came under orders of Thuillier as DSG. though corresponding direct with Waugh as STS. *re* comps. [71, 354–5, 372, 501].
Major work of Calcutta office was now the closing of comps., distribution of errors, and completion of prof. reports of subordinate merdl. ser. of NE. Quad. [126–8] and of Bombay trgn., so far available. A report on the work completed since May 1849 was submitted by Radhanath in 1856; this contains no ref. whatever to NE. Longl. ser. or obsns. to snow peaks which were dealt with by section at Dehra Dūn under Hennessey. This is of particular interest in view of suggestions that have been made that Radhanath was responsible for deducing height of Mt. Everest [IV, 462; V, 90, 343].
An important part of his duty was supervision of comps. carried out by fd. parties, and notice to SG. and officers in ch. of any departure from established rules [126–7].
During 1849–50, Radhanath assisted Thullier and Smyth in preparation of *Manual of Surveying for India*, *re* traverse and trig. comps. [284][2]. In preface to 1st edn., 1851, the authors make due acknowledgement;

"In Parts III and V the compilers have been very largely assisted by Babu Radhanath Sickdhar, the distinguished head of the Computing Department of the G.T.S. ... It would be difficult for the compilers to express with sufficient force the obligations they thus feel, ... not only for the portion... which they desire thus publicly to acknowledge, but for the advice so generously afforded on all subjects connected with his own department"[3] [284].

This acknowledgement was reproduced in the 2nd. edn. of 1856, but was omitted in the 3rd edn. of Sept. 1875, in which though the early chapters on traverse and trgn. appeared in much the same form as before no mention was made of Radhanath's contribution. This was strongly criticised in the local press[4] in articles and letters contributed both by a serving officer, John Macdonald, and by Walter Sherwill who had been many years retired, and as Macdonald had made unseemly criticism, not only of the prof. character of this 3rd. edn., but also on the SG. and the Govt. of India, he was sharply reprimanded and reduced in seniority [512].
Besides routine work Radhanath was engaged during 1850–1 on *A Set of Tables for facilitating the*

[1] DDn. 32 (102–5), to Tennant, Calcutta, 21–2–57. [2] DDn. 474 (285), DSG. to SG., 9–5–50. [3] Thuillier & Smyth (viii). [4] *Friend of India*, 6–9 & 11–11–76; *Govt. Gaz.* 16–10–76.

Computations of a Trigonometrical Survey and the Projection of Maps for India [123], based on formulæ authorized by Everest, and in some cases modified by Waugh or Radhanath himself. Though Radhanath's early mathematical education had not been wide, he had the advantage of sound training in fundamental principles, and readily absorbed everything that Everest passed on to him.

His first edn. was printed in Calcutta during 1851 and comprised Tables I to XVII, with details of the formulæ on which they were based, 27 pages in all. 2nd edn., known as *Auxiliary Tables*, 36 Tables in 119 pp., was prepared and issued at Dehra Dūn by Hennessey in 1868 [10, 122–3].

On tr. to Calcutta in 1849 Radhanath lost the one-third up-country increment on permanent salary of Rs. 400 which De Penning had drawn in addn. to Madras pension [IV, 430]. SG. strongly supported his appn. for an increment, pointing out his work on the new Deptl. Tables, and the special studies of his leisure hours. "I have made myself acquainted" he writes "with the most approved modern works, English and French, on the subject of Geodesie [including Puissant's work of 1842], and such branches of pure and mixed mathematics as are connected therewith, never sparing time nor expense"[1].

Waugh urged his great value to the Dept., and the danger of losing him. He had "for some time past been using his interest to find other employment, and *inter alia* he came forward on a late occasion as a candidate for the native magistracy of Calcutta [IV, 461; V, 446]. ...

"The qualifications...of Chief Computer are very rare, and his loss would be much felt, especially in the present stage... when so much work has been done in the field and is being brought up in office ... I am naturally anxious that services of a person so well trained...should not be lost. ... This is... a case of long continued exertion in an arduous profession, unremitting self cultivation, and professional merit. The masterly character of the papers contributed by him to the Manual of Surveying has been favourably acknowledged in the Calcutta Review, as well as the remarkable purity of his style of writing, and severe accuracy of his language. ... He is without doubt the most scientific native India has produced."

Govt. considered that salary of Rs. 400 pm., was sufficient[2], but increment was not long delayed. On rett. of Vincent Rees, Radhanath was appd. to ch. of SGO. Obsy. 9–10–52 and this carried an addl. salary of Rs. 200 and entailed the regular obsn. of Time and daily signals to Ft. Wm. [140–1, 355].

In the course of these duties Radhanath was led into unfortunate disputes with Thuillier to whose direction he was at first reluctant to submit. The intervention of the SG., however, brought his full apologies and acknowledgement of the DSG.'s rightful authority. Radhanath had resented what he considered interference with prof. work; the DSG. thought only of the successful working of the signals[3] [537].

Though Radhanath and his Calcutta section had no share in the computation of obsns. to Mt. Everest and other snow peaks, he was constantly consulted by Waugh regarding refraction and the formulæ for vertical angles. To his reference regarding the name Mt. Everest and height 29,002, Radhanath expressed his "gratification at the highest snowy peak known in the world being named after Col. Everest, our late master. At the same time...it would have been more natural if the local name was adopted". Waugh replied that "if it has a local name, which is doubtful, it can only be ascertained by travelling to its neighbourhood in Nepal, which is a political impossibility" [90, 94–6, 135][4].

In Oct. 1855, Radhanath thanked Waugh for having put him forward for increase to Rs. 600 pm., the same salary as for the Ch. Civ. Asst. [405], which was not approved. He complained of having been out of health; "For the last two or three years I been constantly talking of going to England but have not up to this moment seriously entertained the proposition. The consideration which has prevented me is the cost of living and travelling in England, which I have heard is very heavy. In 1860 I shall be quite delighted to accompany Mrs. Waugh and yourself to England. No long preparation will be required; in three months time I will be able to make all the necessary arrangements"[5].

He discussed the prospects of the Calcutta money market and the effect of export of silver; "In consequence of the high price of money I have not been able to realise much in the way of profit from my transaction with the Bara Bazar property[6]". In Aug. 1858, he was residing in the neighbourhood of Chandernagore, travelling by train to and from office. In 1862 he bought a "garden house" in Goodalpara, where the jute mills of that name are now situated[7].

After Waugh's rett. in March 1861, Walker became STS., and arranged concentration of all computers at Dehra Dūn [356, 417]. Radhanath took opportunity to resn.; "As after an uninterrupted and protracted service of almost 30 years I begin to feel my health and strength on the decline, it is my intention, on completion of the work, to undergo the usual medical examination with a view of obtaining a superannuation certificate"[7] [520].

He retired on pension from 16–3–62 [344].

RENNY (-TAILYOUR), Thomas [IV, 462–3].

Ben. Engrs.

b. 18–3–12. d. 3–1–85.

2/Lt. 4–11–29...Capt. 4–11–48; rot. as Hon. Maj. 28–11–54.

Son of Alexander Renny-Tailyour (1775–1849), of Borrowfield, co Forfar—who added surname Tailyour on his mother's death in 1806—and Elizabeth his wife, dau. of Sir Alex. Ramsay, Bart. of Balmain.

ed. Tours, France; Addiscombe, 1828–9; Chatham, 1829–31.

m., 9–6–47, Isabella Eliza, dau. of Maj. Adam Atkinson of Northumberland; added name Tailyour 16–11–49 [19 n., 379]. Father of Henry Waugh and Thos. Francis Bruce, both RE. and good cricketers. The latter served with R. of O., 1888–1929.

Conolly (88/170); Markham (108 n); Hodson, IV [230, 604).

Arrd. India 8–3–31; appd. 2nd Asst. QMS. 23–7–32; emp. 1832–42 on Gt. Arc and Amua ser.; 1842–3, Budhon [10, 100–7, 109, 413, 416].

1–10–43, left Dehra Dūn in ch. Malunchа ser., but receiving orders on march to join Gough's army before Gwalior handed over to Clarkson in Dec., and served as Bde. Maj. at battle of Māhārājpur, 29–12–43 [12, 14, 361–2, 379].

Rejoined party, 27–3–44, in Santāl Parganas, having reported on poor progress of Karara ser. on journey down [IV, 463; V, 101, 530]. After selecting stations N. of Bhāgalpur handed over to Clarkson 1st June and proceeded on furl [160, 163, 456].

[1] DDn. 570 (1), Radhanath to SG., 1–3–52. [2] DDn. 542 (306), SG. to Mil. Dept., 18–5–52; BMC., 25–7–52. [3] DDn. 664 (245), DSG. to SG., 19–9–58; (303), Radhanath to DSG., 14–10–58. [4] DDn. 662 (237), Radhanath to SG. 11–8–58; 671 (84), SG.'s reply, 25–8–56. [5] DDn. 670 (61), 30–10–55. [6] ib. (25), to DSG., 8–8–58; DDn. 664 (245), DSG. to SG., 10–9–58 (para 25). [7] DDn. 34 (32), to STS., 12–6–61.

Whilst in England emp. on comparison of the Indian standard bars with national standards, bar B having been sent to Southampton early in 1844 [IV, 47–8].

He kept close touch with the makers during construction of the new 24-inch theodolites by Troughton & Simms and Henry Barrow, arranging their despatch in separate ships. [153]. He made himself "acquainted with...progress of the English Trigl. Survey...under Col. Colby, and has...actively engaged in railway surveys"[1].

At the SG.'s special request for his asstce. at meast. of Sonakhoda base-line, he sacrificed a month of his leave, leaving S'hampton 20–7–47, and travelling with his lately married wife overland via Suez. Arrd. Calcutta 4th Sept. and joined SG. at Darjeeling 1–11–47. After meast. of base-line marched up to Dehra with Waugh, leaving Purnea 29–1–48 and reaching Dehra 3rd May [337].

1–8–48, took over ch. Maluncha party and marched it down to Sironj to start Gt. Longl. ser. across Rājputāna [2, 37–8, 72, 98, 113, 115, 132, 149–50, 415, 532]. His wife and her companion Miss Caird accd. him, a small dau. having d. in Mussoorie two weeks after birth in June.

With Strange as asst. carried approx. ser. a full 220 m. and completed obsns. at 13 prcpl. stations, spending rains at Nimach [37–8, 100, 376, 405]. Rivers of Bombay party had joined for fd. season, SG. hoping that he would profit from Renny's experience though Rivers did not appreciate his loss of independence [56, 392–3, *inf.*].

6–9–49, handed over ch. to Strange to take ch. comps. and fd. office at Dehra. The Ch. Compr. had been tr. to Calcutta [341, 521], and SG. was frequently on tour [337–8]. His eldest son was b. at Mussoorie 9–10–49.

19–7–50, appd. Astr. Asst., a post held by Wilcox, 1832–5, and Waugh, 1835–43 [90, 127, 136, 341–3, 379–80, 394, 501]. Held SG.'s complete confidence [543].

Season 1850–1, emp. with John Peyton on revision of w. section of NE. Longl. ser., conng. Gt. Arc. with Budhon and Ranghir ser., handing over to Peyton at end of Feb. [IV, pl. 4 ; V, 16, 21, 30, 63, 86, 92, 153, 346]. His 2nd. son Edw. Ramsay was b. at Dehra, 8–3–51.

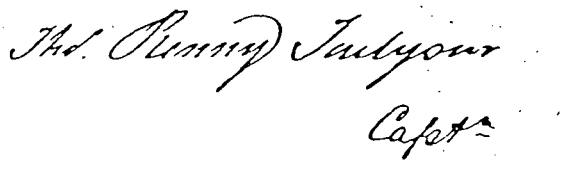
1851–2, in capacity as Astr. Asst., constructed temporary obsvy. on Banog HS. for obsns. of lat. and Himālayan attraction, and barometer experiments [90, 133–4, 530]. Had long corr. with Mussoorie Municipal Comnrs. and Civil authorities on the Svy. claim to occupy about 7 acres at the summit. Instructed young officers, incl. James Walker, at this obsvy., which was eventually abandoned as being too distant for constant use [137–8, 539].

On death of his father, 18–11–49, Renny succ. to family estates, Borrowfield, co. Forfar, and in 1851 warned SG. of wish to retire at close of fd. season 1852–3, but as no mil. officers could be released during the Burma War [194–5], his rean. had to wait till 1–1–54. He sailed from Calcutta a week later with wife and 3 children [43, 339, 382, 399, 414 n.3, 417].

In statement of services dated 1–1–50, he showed date of 1st comn. as 12–6–29, with war medal for service at Māhārājpur, "being attached to the cavalry div., under M Gen. Sir Joseph Thackwell for that day, and his services acknowledged...in despatches, GO. GG. 4–1–44 "[2].

After ret. lived on family estate nr. Montrose, becoming JP. and DL. of Forfar, and comdg. local Volunteers. Was a keen rifle shot, and won Queen's Cup at Wimbledon[3]. Lost money in attempt to develop clay and coal at Borrowfield and moved with family to smaller house on the estate[4].

Compare this autograph as sd. after 1849 with the earlier one of volume IV, p. 462.



RIVERS, Harry [IV, 464]. Bo. Engrs.
b. Cape Town, 4–12–21. d. 4–12–88.
2/Lt. 11–6–39 ... Col. 24–10–64 ;
ret. as M. Gen. 14–4–65.

Son of Harry Rivers, Civ. Conr. Twellendam, Cape Town, SA. and Charlotte Johanna his wife, dau. of Pieter L. Cloete and wid. of Col. Ronald Campbell.

ed. Addiscombe. Conolly (106/115).

GO. GG. 10–6–42, appd. 2nd. Asst. GTS., joining at Poona 9–8–42 ; assumed ch. of Bo. trgn. from Jacob 9–1–43 [382]. 1843–4, completed S. Konkan ser. to Goa frontier [54–5, 62, 72, 122, 379].

1844–5, failed to carry N. Konkan or Singhi ser. beyond Narbada R., being held up by foul weather and continued sickness of whole party [55, 99, 366, 460–1, 467].

18–4–45, promoted 1st Asst. GTS. @ Rs. 618 [381].

1845–6, carried Khanpisura ser. N. from Ahmadnagar to Mhow. During season 1848–9, owing to accident to theodolite and difficulty of replacement, SG. also being dissatisfied with the quality of his obsns., worked with his party on Gt. Longl. ser. under Renny. Taking this as slur on his own capacity, returned to Mhow for the rains instead of joining Renny at Nimach, as desired by SG. [30, 56, 101, 156, 162, 391–3, *sup.*].

1849–50, with new theodolite, took Aramlia ser. to Ajmer, this becoming S. section of Gurhaghat Merdl. After recess at Nimach took Abu ser. S. to Ahmedābād but failed to connect with sea-level on Gulf of Cambay [159]. Carried trgn. W. into Kāthiāwār, and in March 1853 took furl. after handing over to Nasmyth [3, 50–1, 54, 56–7, 103, 117, 191–2, 380, 399].

6–4–54, wrote to SG. from RIUS. Club, 14 St. James' Sq.,[5] London, asking why he had received no official appreciation of his services, nor any reply to letters written to SG. before leaving India. Waugh replied that he had not written because of constant touring and lack of opportunity ; he did not know Rivers' home address ; "I fully admit that it was unhandsome to allow an officer of your standing, zeal, talent, energy and activity, to depart coldly without a word of acknowledgement of your arduous services of 11 years. ... I am, however, much obliged to you for having brought the omission to my notice. ... I shall...prepare a supplement to my report and take steps to have the omission inserted in the orignal".

[1] DDn. 461 (235–6), Renny to India Ho., 27–3–47.
[2] DDn. 569 (80), Camp Kota, 1–1–50.
[3] *County Families*, 1864.
[4] later No. 16.
[5] now held at Bisley.

As amendment to his earlier report, he called attention to Rivers' work; "I most willingly bear testimony to his talents, zeal, activity, and energy, for which...he has always been conspicuous, and is in fact second to none"[1].

On return from furl., Rivers wrote from Mahābaleshwar, 6-11-55, offering his services to GTS.,; "I am not as strong as I was and could not now stand the hard work I used to go through. ... I believe I am far better qualified now than when I was appointed a 1st. Assistant, and shall be glad to place myself again under your orders, for though there may have been some misunderstandings I...shall always recollect...my official connection with you"[2].

Waugh wrote a long letter in reply. He pointed out that if Rivers rejoined he would stand next senior to the SG. which might be resented by the 5 officers appd. 1st. Assts. since he left on furl.; their consent would have to be obtained. And, as regards strength and activity, no promise could be made of light work; "If avowed diminution of physical strength and stipulations as to the nature of employment...would be embarrassing in the case of an ordinary officer, they would be altogether incompatible with the position of the senior 1st. Assistant. He should be a model and example to the whole Department. He must be prepared to go where duty calls, to occupy the post of honour, and contend with difficulties where they happen to be greatest. ... In fact at this time I want a senior officer of more than ordinary vigour".

If Rivers made official application for reappt., SG. promised to lay this before the other 1st. Assts. and then before Govt.; "Kindly send this letter to Nasmyth to read, and if you have any doubts about applying consult some judicious and experienced friend such as the Chief Engineer"[3].

No appn. was submitted and Rivers had a successful career in the Bombay Engr. Dept.; 1857, was Supt. Engr. Rlwys.

ROBINSON, Daniel George, Ben. Engrs.

b. 8-3-26.

d. at sea homeward-bound, ss. *Travancore*, 27-7-77.

2/Lt. 9-6-43 ... Bt.-Col. 21-12-67.

Son of Daniel Robinson, Col. in Spanish army, and his wife Mary Anne.

ed. Addiscombe, "first mathematician and first engineer cadet of the term which left...in June 1843".

m., Mussoorie, 9-9-51, Jane Amelia, dau. of Henry Graham. FRGS. 1859; GB.

DNB.; *Addiscombe* (223); Markham (121 n); *REJ.* VII, 1877 (93-4); *Journal Telegraphique*, 25-8-77; *RGS. Progs.* 22, 1878 (347); *Ubique*; Thackeray (223); Conolly (90/221); Sandes, II (200 n.1, 281-2, 284); portrait, pl. 24.

arrd. India 1845; at battle of Sobraon, 10-2-46; with Ralph Young survd. N. bdy. of Punjab when under settmt. by James Abbott; GO. GG. 12-8-47, placed under orders of Resdt. Lahore for mil. svy. of Hazāra, lately tr. from Māharāja Gulab Singh to British; svy. carried out under Lt.-Col. Napier [208-9, 317, 363, 544].

"The establishment sanctioned was ample but not procurable. In the time of the Sikh dominion Hazāra was always more or less disturbed, and was as much dreaded as the Khyber Pass and, as two new revenue surveys were started at the same time [269], who offered the same salaries, I never received a single application...in answer to my advertisements [423].

"I was training a munshi and two European n.c.o.s of the Sappers and Miners...when the campaign of 1848-9 broke out, and put a stop to our operations. ...

"The three European civilians appointed as assistants had little education and no knowledge of survey. Two of them left on better appointments very shortly, and the third had to be discharged" [423][4].

Route svys. between Wazirābād and Hasan Abdāl made by Robinson and his assts. were the only maps available to the army on the outbreak of the 1848-9 campaign. Robinson himself joined James Abbott at Haripur in May 1848, and served at battles of Chiliānwāla, 13-1-49, and Gujrāt, 21-2-49. He gives following account of his mil. services in the two Sikh campaigns;

1846, comdd. company of S. & M. with Army of Sutlej; proceeded to siege of Kāngra in comml. of 3 cos. of S. & M., 1846-7; on surrender of Kāngra, whilst in comml. of escort of Bdy. Comnr. made mil. svy. of country on either side Jummoo-Lahore bdy. from Beās to Indus; 1847, appd. by Sir Henry Lawrence to make svy. of Hazāra[5] [272 n.3].

On resuming svy. in April 1849, ordered to complete it that season, and "these instructions compelled me to hurry over the work in a less accurate and detailed manner than I wished". Worked right through the rains, and on return to Lahore was on sick list for several months [209].

May 1850, the Lahore Govt. asked SG. to take over Robinson's services for a svy. to stretch across upper Punjab and cover trans-Indus districts [209-10, 380].

They suggested that Robinson, who was recuperating at "Shoojanpore" on the Rāvi, might be "removed to your neighbourhood for...instructing him in the geographical points which the surveys of the Punjab are expected to subserve. He might with advantage join you at Mussoorie and remain there till he can take the field next cold season"[6].

Appd. to GTS. from 19-7-50 on Rs. 618 pm., "but never enrolled amongst the regular Assistants of the GTS.; neither did he receive designation as 1st Assistant, but has always continued attached to the Topographical branch"[7].

Season 1850-1, emp. on svy. of Jammu-Punjab bdy. to complete svy. commenced in 1846, making complete resurvey of stretch between Rāvi and Jhelum [119, 157, 209-10, 337, 363]. Returning to Dehra 8th June 1851, set out 4 mo. later to take up svy. of Jhelum and Pindi dists. that occupied him for next 8 years [7, 37, 113, 210-4, 377].

Commenced with small party of 3 sub-assts. and from 1852 made recess qrs. at Murree.

During his first summer there the Lahore Govt. asked for his services to lay out a hill road beyond Murree, but, replied the SG., "as the office business of his survey is considerably in arrears, I am...apprehensive of distracting him from his regular duties. ... The tracing of the proposed mountain road should be left to Lieut. Robinson's public spirit to undertake during his leisure, and...the business should be arranged between the Commissioner and himself"[8].

During residence at Murree took up "an unappropriated site for...building a house. ... The said site is as yet known by the name of Rosenhinde; is bounded to the south by the streamlet which also forms the northern boundary of Hackthorne; to the north by the cliff overhanging the next northern streamlet; to the east by the cliffs of the forest, and to the west by the cliffs falling towards the eastern branch of the Hurra River"[9] [469].

On this Pindi-Jhelum svy. Robinson proved himself a topo. survr. of highest talent. Guided by

[1] DDn. 592 (54 B), from Rivers; (54. A), SG.'s reply, 17-5-54; 547 (230), SG. to Mil. Dept., 17-5-54 ackd. GO. to R., 4-10-54 (7); 546 (435). [2] DDn. 592 (357). [3] ib. (361), 21-11-55. [4] DDn. 533; M 398; DGR. to SG. 1-12-55; 500, Lib. J. 7.73; Ingram emp. 1855 on Dacca-Arakan rd. (423 n.2). [5] DDn. 42 (609), 15-12-65. [6] DDn. 548 (2), Bd. of Admin., Lahore to SG., 27-5-50. [7] DDn. 21 (87), SG. to Mil. Dept., 17-6-61. [8] DDn. 548 (18), Bd. of Admin. to SG., 11-5-52; 713 (27), SG.'s reply 31-5-52. [9] DDn. 712 (97) und., pr. 1852.

Waugh's *Instructions for Topographical Surveying* [282], he brought the art of planetable svy. to the highest pitch, and himself drafted a note that was embodied in the deptl., handbook and remained "the last word" for the next sixty years [289–90][1].

His party became the regular training centre for topo. training for all suitable assts., and from 1853 to '58 his leading survr. and dmn. John James set the standard for deptl. topography [4, 10, 124, 144, 231, 285–7, 291, 317, 414, 424–5, 427, 446–7].

During 1857 he and his party "rendered good service during the petty rebellion near Murree; ... from his knowledge of the people and country was able to make himself most useful [482]".

1860, on completion of the Pindi–Jhelum svy. party was tr. to svy. of Gwalior and Central India [189–90, 214, 518]; Robinson took a month's sick leave from 20–3–63 after shooting accident; a bullet through his right hand. From 10–11–63, acted as STS. during Walker's absence on furl. and then as DSG. Rev. Svys. 25–4–65 when Thuillier took furl.

For some years found situation and prospects with Svy. compared unfavourably with those of his contemporaries in other services. Waugh pressed his immense value as topo. officer, but Govt. refused to take any action until Thuillier raised the case very strongly. They then raised his staff salary to Rs. 800 pm., "or that of a Superintending Engineer" [527]. They did not, however, agree to a special topo. charge for him in Central and Western India [387–8][2].

Protested against Walker's appt. as STS., Walker being his junior both in mil. 1st comn. and appt. to Svy [388].

Though loth to leave the Svy. accepted appt. as DG. Telegraph Dept. to act from 24–7–65 being confirmed the following year; "During his tenure of 12 years the telegraphs spread over India and were connected by overhead and submarine cables with England. His zeal, activity, and marked administrative ability enabled him to place the Indian Telegraph Department on a thoroughly sound footing. ... His death in 1877 while on his way to England was a heavy blow to telegraphic progress in the East [141, 388, 400]".

ROW, William Skene. Ben. Inf. & sc.
bapt., Calcutta, 18–7–24. d. 16–7–78.
Ens. 23–2–42 ... Bt.-Col. 23–2–73;
ret. as M. Gen. 5–10–74.

Son of John Row., Surg., Ben. Med., and Charlotte Emma his wife.

m., Hove, Sussex, 30–11–59, Frederica Esther Emma, dau. of Joseph Amesbury; twins, son and dau., b. Hazāribāgh, 12–8–60.

from 23–11–53, Ex. Offr. PWD., embankments, Balasore.

27–1–56, appd. Asst. Rev. Survr., No. 2 Div., Burdwān, Smyth commending his "knowledge of surveying and levelling" and hard-working and business-like habits.

1–10–57, on Smyth's departure on furl., assumed ch. and moved party from Nadia into s. Dināj pur. "Being very weak in health, and wanting in the energy and power of supervision which are essential to success, had very poor season's work [243, 251, 398]" 16–12–58, furl. on mc. under GO., 17–1–59.

May 1860, on return from furl., appd. to No. 6 Div., Hazāribāgh, and term "probationer" now dropped. On appn. for independent ch., SG. replied, 24–6–61, "Looking to the requirements...essential in an officer conducting independent operations in a difficult country, ... and having in mind your management in Dinajepore District, ... it appears to me impossible to comply with your wishes. ... I am fully persuaded of your value as an office man, ... or in any branch not requiring very great personal exertion in the field"[3].

Promoted to Rs. 350 pm., after inspection of party by SG. 31–7–66, resd. at his own request, being commended by SG. for "amiable and conciliatory character"[4] [400].

SAXTON, George Harper. Mad. Inf. & sc.
b. 29–1–20. d. 20–1–1901.

Ens. 11–1–38 ... Maj. 31–12–61; MSC. 18–2–61 ... Bt.-Col. 11–1–69; ret. as M. Gen. (1–7–74)/16–7–75.

Son of Chas. Saxton (b. 1783), organist, of Dodington, Whitchurch, Salop, and Anne Maria Scoltock his wife.

ed. at private sch., Whitchurch.

m., 1st., Secunderābād, 23–7–45, Fanny Maria (Frances), dau. of Peter Harris Abbott', official assignee bnkpy.. court, Madras, and sis. of M. Gen. H. D. Abbott (1816–92), Mad. Inf., DS.; two of their 5 children d. in infancy, and she d. 30–7–55, under tragic circs., aged 33, on boat journey up Māhānadi R., a few mo. after birth of dau., Fanny, who m. Rev. E. A. Oram (1846–1913).

m., 2nd., in England, before 5–7–57, Eliza Julia, aged 20, dau. of Henry S. Boulderson, BOS. [IV, 100, 479]; she had one son and 4 daus., and d., Woking, 29–6–1917.

FOS. 1857; FRGS. 1898.

GR. Topo. 1872–3 (14); ob. notice, *GJ.* XVII, 1901 (539–40). Portrait [pl. 26] from oil painting by Chas. Baxter (1809–79), *DNB.*, taken during furl. 1856–7.

arrd. India 14–5–38, and posted 38th MNI.

MGO. 24–4–49, "a patronage man"[8] without previous svy. experience [385–6], appd. to ch. Ganjam topo svy., joining Coast ser. GTS. 11–7–49 for training under Thorold Hill at Midnapore.

Hill reported 24–8–49, "Saxton...has good abilities and is attentive to work. This wet weather he is practising at computing, etc.; ... I shall now put him to work on principal angles and probabilities, spherical excess, and...principal triangles, and after that we will go to the latitudes and longitudes. ... As soon as the weather will permit we will go to work with the planetable, ... but it rains so much now and is so damp that we must wait a little"[9].

[and later] "He has completed a survey with the planetable on a large scale of the city of Midnapore, the cantonment, civil station, and their environs. ... Has also had practical instruction in observing a circumpolar star with the great theodolite, and also in observing azimuthal terrestrial angles. He has also practiced ray-tracing with the small theodolite, and seen the method of building towers, and selecting principal and secondary stations, and is now employed on a minor series in the valley of Subanrika River with the 12-inch theodolite, and also at the same time filling in the details with the planetable".

"In my opinion he is perfectly qualified to proceed to take charge of the party in Ganjam"[10].

Appn. for posting to GTS., being refused, he assumed ch. of Ganjam topo. party at Berhampore during May 1850, with the usual Madras designation ASG., and staff salary Rs. 350 [363–4, 421].

Taking the fd. during Dec. for svy. towards Angul, he had to return to cantonments the following month having "with two of his assistants and a considerable proportion of his establishment...been attacked by sickness of a serious

[1] Markham (121n.); *Handbook of Topography* ch. V, *Planetabling* (9). [2] DDn. 643 (187), SG. to Mil. Dept., 5–10–57. [3] DDn. 714 (151), DGR. to SG., 30–5–59; DDn. 2 (188), Waugh to Mil. Dept., 1–3–61; 713 (310), Thuillier to Mil. Dept., 17–6–61; Govt. authority, BMC., 14–8–61. [4] Thackeray (223); Sandes, II (281–2). [5] DDn. 43 (7). [6] *GR. Rev., 1857–8.* [7] spelling from family letters; infn. from family records has been liberally supplied by g. dau. Miss E. M. Oram and by Comdr. S. W. Saxton, late RN., g. son of Dr. Chas. Saxton. [8] Patron, Sir Henry Pottinger, Govr. Madras 1847–54 [II, 437–8]. [9] DDn. 507 (55). [10] DDn. 599 (5), 29–3–60.

character, from the effects of which Lt. Saxton now lies dangerously ill at Cuttack" [462–3]. ... This sad disaster is the more to be lamented inasmuch as great pains had been taken to train Lt. Saxton to his duties, and he had entered on them with commendable zeal and energy"[1].

Things went better next season working sw. through Tributary Mahāls, renowned for their atrocious climate, but to escape risk of fever Saxton only stayed out 3 mo., Jan. to March, completing a good area of trgn.; "I have gone through immense exposure, both day and night, and tho' I have... enjoyed excellent health, such...exposure must be prejudicial to health in time"[2]. The outturn of planetable svy. was also good [26, 289].

Waugh was pleased with the results; "This is the first season for years that anything systematic has been accomplished, and a moderate quantity of work obtained without accident and disorganization. ... The success you have achieved is fairly attributable to your able management"[3].

He attributed the better fortune of Saxton's party "to my having postponed the usual date for taking the field, and to the precautions suggested in my medical instructions. ... Captain Saxton reported that he was successful in the treatment of all cases, and that a general confidence had been thereby inspired among the establishment [464]"[4].

He went on to recd. Saxton for a special increase of pay which the Directors sanctioned under their letter of 22–3–54 [385, 398].

Saxton was on excellent terms with the pol. authorities, and on 7–9–53 was gazetted Asst. to AGG. on SW. Frontier, who found him "an officer of great experience, ... very conciliatory in all his dealings with these rude tribes"[5]. This magisterial post was of particular value in settling local boundary disputes [285, 527].

Under *Govt. Gaz.* of 18–10–53, qualified as interpreter in the Oriya language, and claimed that there was "only one other officer in the whole of India passed in Oreah". He had already passed in Persian and as Interpreter in Hindostani and Telegu.

Saxton had long been interested in geology, but the SG. did not encourage such distractions from his prof. duties as survr. [142–4]. The Madras Govt., however, had asked him for reports[6] and, writes Saxton later, "I supplied myself with a few geological tools and collected some specimens of pebbles and rocks which...were submitted for examination in the Calcutta Museum, but were not of much interest. I engaged a villager near one of the principal rivers...where the sand...had for ages been searched and washed for gold... used for ear ornaments, etc., worn by the women. I watched the...process which took the whole day with a resulting bit of gold not larger than a pin's head."

He watched the village iron-smelters produce "a lump of iron enough to make one or two tree-felling axes. I wrote an account of these rude processes with diagrams, which were published in the Bengal Asiatic Society's Journal. ... I devoted a few days to visit the Talchir coal field which...had never as yet been visited by any European. ...

"In the year 1856–7, when in England... —the only furlough I ever had during my 36 years of Indian service—I... applied to...the School of Mines, ... attending...a full series of lectures, ... at the conclusion of which I...was elected a Fellow of the Geological Society"[7].

Early in 1852 he had asked for a young mil. officer asst., and the SG. agreed that it would be "a measure very desirable for its efficiency"[8].

"The patronage rests with the Governor or Governor-General, and I can only...recommend when the professional qualfications are of the highest order, ... otherwise my interference in a question of patronage would be improper. If you know of anyone of high mathematical attainments and qualifications as a draftsman, I think the bringing forward of his name would be well received"[9].

It was not until July 1854 that Depree, a nephew of Saxton's, was free to apply for appt. which was approved under GO. GG. in C., of 20–10–54 [171, 386, 495–6], and Saxton was delighted when he joined in Dec. About the same time the SG. protested against a call from the Madras Army for Saxton's return to mil. duty, and obtained orders from the Supreme Govt. for his retention with the Svy.[9] [382].

From about 1852, Saxton had obtained permission to spend some weeks every year at Puri on the sea-coast [386] and he took advantage of this regularly for his wife and children during the hot weather. He had been anxious about his wife's health for some time before the birth of a dau. at Puri 6th May 1855, and he asked for a month's leave from Cuttack, writing 21–7–55, that he might take her down to Calcutta for journey to England. She got ill on the way and died on the river boat coming back from False Pt. lighthouse only 9 days later. The river was in flood and it was five days before the boat could be brought up to Cuttack where she was bur. on 4th Aug.

It was under the strain of these troubles that Saxton wrote an unwise letter to SG. pressing for his transfer from the Madras terms of service to the more generous terms of the Bengal Govt. Waugh insisted on its withdrawal with full apology. Saxton readily complied [395], but had lost his opportunity, and it was not until 1859 that the Madras topo. survrs. were brought into line with their bro. offrs. of Bengal [399, 455].

He applied in Nov. for 15 mo. leave on mc., first to Calcutta and then "to embark finally from the port of Madras as I have important matters to arrange there." Leave was sanctioned under GO. of 7–1–56 and 22–2–56, and he handed over to Depree 8–4–56. Sending his 3 children by the Cape route with a friend, he himself travelled overland by Suez [IV, 175; V, 386, 426–7, 429].

Shortly before the end of his furl. he married for the 2nd time and whilst in Paris at the start of the return journey overland they received, 9–7–57, a telegram from the bride's father advising her to abandon the journey on account of the outbreak of the Mutiny. They took no heed and Saxton resumed ch. from Depree on 2–9–57. The Orissa svy. had now been expanded to two parties, Saxton having general responsibility for the respective programmes, and both parties coming under the orders of the DSG. [4, 173, 477].

Owing to the disturbed state of the Sambalpur area, work was diverted for one season to trgn. of the coastal strip and in Jan. 1858, Saxton took up work nr. the Chilka Lake and worked N. towards False Point. Work was much impeded by very thick jungle and the multitude of small tidal creeks [28, 173–4, 283].

Waugh was not at all pleased with the work of season 1858–9, through the rough country of the Tributary Mahāls towards Sambalpur; he thought Saxton had cut his fd. season far too short, and had not pushed the svy. on with vigour. He criticised the maps and drawing. 'Saxton's

[1] DDn. 592 (195), SG. to Mil. Dept. 30–1–51. [2] DDn. 591 (181), to SG. 16–3–52. [3] Ib. SG. to Saxton, 5–5–52.
[4] DDn. 549 (63), SG. to Mil. Dept., 19–9–55. [5] DDn. 548 (52), 6–11–54. [6] repeated by Mil. Dept. to DSG., 3–1–55.
[7] GHS. memo. of 20–3–1900. [8] DDn. 591 (242), SG. to Saxton, 7–9–52. [9] BMC. 29–10–54.

GEORGE HARPER SAXTON

(1820–1901)

Uncle to Depree

Madras Infantry

Topographical Surveys 1849–74



G. H. Saxton, Lieut

GEORGE CHARLES DEPREE

(1832–87)

Bengal Artillery

Topographical Surveys 1854–83

S.G. 1884–87 [also pl. 24]



G. C. Depree. Lt



Radhanath Sickdar
Chief Computer.

RADHANATH SICKDHAR
(1813-70)

Appointed Computer G.T.S., 1831
and Sub-Assistant Surveyor, 1832
Chief Computer 1845-63

reactions were strongly expressed, and brought a sharp rebuke, Waugh writing to the DSG. that "the tone and style of this correspondence is not satisfactory. ... Captain Saxton must conform to the judicious orders given by the Deputy Surveyor General [174–5, 282–3, 291, 367].

From 1860, Saxton's party worked southwards through the difficult jungle-covered hills on the borders between Ganjam and the CP. [387, 400].

The Khōnds and other hill tribes were shy and unfriendly, and sometimes definitely hostile; *dāk*-runners and signallers were interfered with, and supplies most difficult to arrange [176–7]. Almost completely cut off from the rest of the Dept., Saxton held on stoutly under the hardships of these desolate wilds, his assts. constantly dropping out under the pestilent climate. In some extraordinary way his health bore up season after season, blessed by the annual retreat to Ootacamund in the Nilgiri Hills where he had a bungalow for several years [167–77].

He worked through part of the country where the Merriah human sacrifices were gradually being suppressed [IV, 484, sv. Human; V, 170]; "The last instance of the rite being attempted, the intended victim—an elderly woman—and some of her several children were rescued before sunrise when she would have suffered sacrifice. ... A strong party of the Sebundy Police corps[1] surprised the assembled crowd and brought away the woman. ... I now have a photo of the woman as she appeared. ...

"My survey duties took me next morning into a hill country where these proceedings had been arrested, and numerous villagers were...hurrying into hiding places all round. As I on an elephant passed through an open cultivated bit of ground, I was no doubt taken for an officer of the dreaded Suppression Department. ... I came near to...the shrine of a former sacrifice. ... I got down from the elephant and took possession of all the rude paraphenalia. ... A great many eyes were peering at me. .... My trophies are now in the Calcutta Museum. ...

"In the adjudicating and settlement of boundary disputes... I had a large experience. As I was invested with judical power [170, 285, 526], I volunteered to undertake official enquiry into boundary cases. ... In this way my Atlas shows several thousands of miles of boundary...clearly defined, between the numerous independent states, ... including...the limits of the two Presidencies. ... The disputes between Bastar and Jaipur Rajahs were so serious that the District...Officers were directed to attend, as my Assessors in one instance, and as Joint Commissioners with myself in a second instance.

"With these exceptions, without the aid of any other official, every disputed bit of boundary was settled by me personally, without a single appeal"[2].

On Robinson's tr. to the Telegraph Dept., 1865, the special allce. of Rs. 800 allowed to him in addn. to mil. pay and allces. was granted to Saxton "in consideration of...long arduous services" [388, 525][3].

One of Saxton's most useful assts. of these later years was John Harper, whom he brought out on his return from furl. in 1857 [422, 431]. Harper had been introduced to him by Dr. Chas. Saxton, his eldest bro., who was hd. master of Newport Gr. Sch.

He was less successful when persuading a nephew of his own to join the party. Chas. Clifford Saxton was b. 19–1–42, son of Dr. Chas., the hd.-master, and comnd. to Mad. Art. 12–6–58. His uncle applied, 28–8–58, for his posting to an Art. unit at Cuttack; "I am convinced that the habits and character of an officer are greatly influenced for good or bad...at the beginning of his Indian life. Having so lately been in England and seen much of my nephew, who is very young, I feel sure my advice would tend to lead him into studious and regular habits[4]".

The nephew was posted to the party under GO. GG. of 2–8–67, but resd. 2–10–67, after only 2 mo. at Ootacamund, to join mil. exptn. to Abbyssinia, where he was mentioned in dispatches. He m. in Dec. 1869 and d., London, 20–2–76.

His tr. to Staff Corps in 1861 had saved Saxton from reversion to regtl. duty on promotion to major, an old rule by which the Dept. had lost many a valuable offr. [384].

Granted 2 years furl. under Mad. GO. 16–12–73, sailed from India 3–2–74 again taking overland route. "I had always intended...to...publish some memoirs...of my experiences, ... but...the steamer on which our baggage was shipped...was wrecked and everything belonging to my family and myself, including...diary and notes, ... was utterly lost.

"My health also, surely the result of remaining so long on such service, ... was for some years in such a threatening condition that...I was induced...to accept the ten years capitalization, and retired, to the very serious detriment of pension and military rank[5]".

His g.dau. writes that he "settled in Exeter where he took part in the life of the city. He was a governor of the Devon & Exeter Hospital, and worked for other hospitals and for all musical activities. ... He learned, at the age of about 70, to play the 'cello'. ... He had strong opinions on bi-metallism, and was an advocate of decimal coinage. ... Late in life I found him sitting in his garden with a large volume of Persian script, reading...Hindustani; I was shown the right to left reading. On Sundays he went to service at the Cathedral. He was a successful rose and fruit grower, budding and grafting his own trees[6]".

After his rett. the SG., Thuillier, sent him a set of the maps pub. from his svys., mounted as Atlas in a case, and in 1884 Depree, now SG., sent him a bound vol. of all his annual reports. In reply to his offer to send these to RGS. he recd. letter from PRGS., Sir Clements Markham, 8–1–99; "If you will send your Orissa Atlas...it will be placed in the Council Room for the Members of the Council to look through it and also in the Map Room until after the anniversary. I shall also be much pleased if you would also send for exhibition the copy of the Saxton Atlas, ... and the manuscript map drawn by Christopher Saxton [*fl.* 1570–96; *DNB.*]. ... The parallel between your Orissa Atlas and that of England by your eminent Elizabethan namesake is very striking". To this Saxton noted; "My work and that of Christopher Saxton were each about 50,000 square miles".

SCHLAGINTWEIT; four bros., Hermann, Adolf, Robert, Emil. German Scientists.

Sons of Joseph Schlagintweit, eye-surgeon of Munich, who d. 1854, leaving six sons, incl.—

Hermann, b. 13–5–26; d., Munich, 19–1–82.

Adolf, b. 9–1–29; murdered nr. Kāshgar, pr. 26–8–57 *JRGS.* 29, 1859 (CXXIX vii–viii), [146, 528].

Robert, b. 27–10–33; d., Giessen, 6–6–85.

Emil, b., 7–7–35; d., Zweibruecken, 20–10–1904.

The 3 eldest bros. visited India between 1854 and 1857, for scientific research; the 4th, Emil, arranged their collections and edited their memoirs in Germany [144–7].

Hermann and Adolf, both interested in geology and magnetism, had explored and climbed in the Alps, and pub., 1850 and 1854, with Robt., two vols. describing their work.

They were anxious to extend their researches to the Himālaya and in 1853, with the strong support of Baron Humboldt and the RS. of London, obtained authority of the Directors HEIC. to pursue magnetic svy. of India broken off by Capt. Elliot's death [IV, 118–9; V, 144–5]. They were to work under ægis

[1] irregular armed police; *Hobson-Jobson*; Sandes, I (457 n.3). [2] GHS., 20–3–1900. [3] *GR. Topo.*, 1864–5 (10). [4] DDn. 728 (2), to AG. Ft. St. George, 25–8–58. [5] commuting ¼ pension, GHS., 20–3–1900. [6] Miss Oram to RHP., 25–10–1957.

of the SG. and were each given reasonable allces. on condition they travelled by separate routes.

Leaving England 20–9–54, they landed at Bombay 26th Oct., bringing Robt. with them; we do not find that he drew any allces.

A general account of their work and travels has been given [145–7], but other details may be added here.

On visit to Kumaun in 1855, Adolf and Robt. engaged Nain Singh and other relatives of Devi Singh, Moorcroft's old friend who was still alive [II, 431; V, 448], and like Moorcroft they visited Gartok in disguise. They climbed part way up Kamet to which they gave the name Ibi Gamin [86–7, 147]; they explored the glaciers of Nanda Devi.

In Dec. 1855, Robt. visited Amarkantak which he had been told was 7,000 ft. above the sea, though no survr. had ever suggested any remarkable ht. [I: 29–30, index; III, 517; IV, 477]. He made it 3,850 by barometer [344].

29th May 1856, Hermann and Robt. left Simla for Leh. Hermann travelled by Upper Sutlej, Spiti, Parang La [202–3, 234 n.5], Tso Morari; Robt. via Kulu, Lāhul, Bāra Lācha La, finding Hermann at Leh 30th June. Leaving Leh 24th July they crossed Saser and Karakoram passes, then east to Kuenlun Range [237–8], claiming to be the first Europeans to cross these ranges [446, 448].

They kept their plans secret; "It was very important... to follow a route not generally taken by caravans trading to Yarkand. ... Our chief guide therefore proposed...a direction without any trace of a road from the Karakoram Pass. ... On leaving Ladak we had nineteen horses with us, of which, however, we lost seven between Leh and Sumgal. On the 13th August, while crossing the Elchi Pass, we were overtaken by a violent snowstorm. The cold was intense during the night, and two of our horses...lying close to our very feet died from the effects of it".

Adolf had left Simla at the same time and travelled to Skardo via Kulu and Lāhul; he had then explored the mountains and glaciers round Nanga Parbat before joining his bros. at Srinagar [76–7].

Early in 1857, Hermann visited Kātmandu and was allowed to make obsns. and sketches "without let or hindrance". Though his obsns. had no fixed base, he was not afraid to dispute the Survey identification of snow peaks, and his claims were not firmly disproved till Wood's visit in 1903 [95].

Sailing from Calcutta Hermann met Robt. in Egypt in May 1857, the latter having sailed from Karāchi, and they returned to Germany together.

Adolf remained behind in order to make another visit to Central Asia and was murdered near Kāshgar. It was several months before his fate became known in India. Enquiries were put in hand in many quarters and infn. was collected from his followers and from people of Yārkand and other places. Henry Strachey in Kumaun, Knox in Kulu, and Johnson at Leh, were amongst those who collected most. From these various accounts it appears that when Adolf reached Yārkand he found it under siege by Turkis from Kokand, some 300 m. w. of Kāshgar. He sent back one of his servants to Kāngra with reports and obsns., and marched w. towards Kāshgar, nr. which place he was siezed by another Turki leader, and murdered with two of his followers. The pr. date, 26th Aug., was deduced from servants' note of new moon [507].

His body was brought back to India by one of his servants, and most of his notes and obsns. were recovered and sent to his bros. in Germany [76–1].

Full reports of these enquiries are to be found in DDn. 646 (481, *et seq.*); 715 (479); 717 (236, 239) 53; (17), and also in *Results of the...Mission*, I (11–65).

Two monumental accounts of *The Results of the Schlagintweit Mission to India*; 2 vols. with Atlas, pub. 1862, Leipzig and London and *Reisin in Indien und Hochasien*, 4 vols. pub. Jena, 1869–80; Emil the yr. bro. asstd. in preparation. Their reports on physical geography and natural products and general description of the country are of the utmost interest and value, and their coloured panoramas and landscape sketches are delightful[1].

They were not trained survrs. nor skilled in the use of survy. instrs., and their geogl. work was sketchy [146–7].

Hermann wrote to STS., 16–8–1868, from Jaegersburg Castle, nr. Toschheim, Bavaria[2]. Both he and Robt. were officially honoured in 1859, Hermann being known as Hermann von Schlagintweit-Sakunlunski. Robt. von Schlagintweit became Prof. at univ. of Giessen in Hesse[3].

Emil (*DIB.*), of Bavarian civ. service, was expert on Buddhism, and on history and languages of Tibet and India, and auth. of several pubns.; he greatly asstd. his bros.

SCONCE, James. Ben. Art. & sc.

b. 2–4–36. d. 19–12–1918.

2/Lt. 8–12–53 ... Capt. 3–4–63 ... ret. 13–4–70; Bt.-Col. 9–12–83; ust.; to mil. dmty, 2–4–91.

Son of Robt. Sconce, Procurator Fiscal & Writer, Stirling, and Agnes Colquhoun his wife.

ed. Glascow univ., matric. 1849; Addiscombe, 1853–4.

m., pr. England, 18–1–66, Frances Susan Kerr; their last surviving child, Ethel Colquhoun, d. at Strathtay 28–3–1941.

Sl. Classd. Lists, 1881, 1884, 1890.

arrd. India 2–4–54; with Art. at siege of Delhi, Sept. 1857, and relief of Lucknow, March 1858; Horse Art. 11–2–58.

21–10–59 appd. Asst. Rev. Survr.; joined Bundelkhand 13–12–59 [267 n.6]; to ch. Jubbulpore Rev. Svy. 27–6–62; Rev. Survr., 24–1–63; furl. mc., 1864–6; ch. No. 6 Div. Hardibāgh 3–11–66; furl. 1872–3; ch. 3 Div. Midnapore, 6–12–73; No. 8 Div., w. Soane Irrgn. 16–3–76 [535].

DSG. and Supt. Rev. Svy. 1–1–79; furl. 1874–6; off. SG. 11–4– to 15–7–89; ret. 2–4–91, aged 55; furl. 27–2–89 [396, 400].

SCOTT, Walter. Bo. Engrs.

b. 2–4–36. d., nr. Dresden, Germany, 19–3–76.

2/Lt. 18–12–24 ... Lt.-Col. 2–7–53 ... Gen. 21–3–75.

Only son of Thomas, bro. of Sir Walter the novelist, and sometime Pymr. HM. 70th Ft., and Elizabeth his wife, dau. of David McCulloch.

ed. Addiscombe. Conolly (105/71).

1845–8, in ch. of Rev. Svy. Canals, and Forests in Sind [192–3, 276, 281, 285, 401]; 1858, in ch. PWD., Sind [76].

SHERWILL, James Lind. Ben. Inf. & sc.

b. 25–12–19. d. at sea, 12–1–64, homeward voyage, E. of Cape [396].

Ens. 24–1–39 ... Maj. sc. 18–2–61.

Son of Markham Eeles Sherwill, Capt. Stafford Militia, and Lucy Maria dau. of Dr. Jas. Lind [1736–1812]; *DNB.*, MD, FRS.; phys. to Geo. III.

m., Dinapore, 17–3–52, Harriet, dau. of Col. John Montgomery Hill, and sis. to his bro. Walter's wife [529].

29–12–43, at battle of Paniar, Gwalior campaign; 1848–9, and 1852, with PWD.; furl. 19–4–52.

26–9–56, appd. Asst. Rev. Survr., Derajāt, under Johnstone [217–8]; qo. 3–1–59, tr. to LP.; assumed ch. Dinājpur Rev. Svy. from Row, 16–12–58; with party to Mānbhum at end of 1861 [6, 243, 254, 364]; "in energy and determination...second to none" [398, 400].

JASB., XXXI, 1862 (457); *Ben. P & P.* (271); with three others visited Sikkim and explored glaciers of Kangchenjunga.

qo. qo. 14–12–63, furl. on mc.

[1] Eur. Letters I (16). [2] *B.M. Cat. Pr.* [3] Eur. Letters (15), 8–6–66.

SHERWILL, Walter Stanhope [IV, 465]. Ben. Inf.

b. 31–8–15. d. 29–3–90.

Ens. 1–6–33 ... Maj. 2–4–59; ret. as Hon. Lt.-Col., 31–12–61.

bro. of James [528].

ed. Christ's Hosp.; Addiscombe, 1830–3; Hodson, IV (74)

m., Ghāzipur, 24–2–45, Cecilia, dau. of J. M. Hill, Comnr. of Port Elizabeth, SA., and sis. to wives of Jas. Sherwill [*sup*] and A. C. Heyland, BCS., judge at Ghāzipur.

FGS.; FRGS. 1859; wrote frequently for scientific journals; *JASB.*, XX, 1851 (544), *Rajmahal Hills*; Sikkim; XXII, 1853 (540–70, 611–38), papers on geology of Kangchenjunga and other peaks; XXIII, 1855 (49–57, 83), *Kunchinjinga*; *Darjeeling*; *Ben. Sel.*, XXIX, on *Rivers of Bengal*, 19–2–57; Oldham; *Ben. P & P.*, 1936 (22). *Cal. Rev.*, 1859, *Gangetic Delta*.

Attractive artistic sketches of svy. life [III, 345; IV, pl. 18; V, 284]; VM. exbt. 1264, sketch of Darjeeling, 1852; col. litho. at IO., Foster (113) [284]; *JRGS* 1859.

arrd. India Jan. 1834; 27–7–38, appd. Asst. Rev. Survr., joining at Cawnpore under Saunders Abbott [IV, 226–7]; 1840–1, leave on mc. to Cape; rejoined under Stephen at Jalaun, holding temp. ch. 1842–3; after move to Bihār [IV, 184, 227] full ch. as Rev. Survr. from Feb. 1844.

From 1844, moved party in succession to Shāhābād, Monghyr, and Bhāgalpur, taking leave on mc. to Cape, 10–3–48 [6, 241, 244–5, 254, 296, 299, 302, 304–5, 364, 395–6, 433–4]; resumed ch. 24–10–49 and moved party to Rājmahāl, Birbhum, and Murshidābād [225, 243, 254–5, 535].

Writes to Thuillier from camp, Christmas Day 1850; "I do not like going into our jungles without elephants; tigers are too numerous to be comfortable. ... A happy Christmas to you and yours. Thermometer about 60°; awfully cold; we are obliged to stand in the sun to warm ourselves".

Again from Berhampur, nr. Murshidābād, 4–5–51; I arrived here late last night having been 24 hours on elephants going 54 miles ... Very tired and knocked up; excuse haste"[1].

During summer months 1850–2, his party made large scale svy. of Darjeeling area, and under his personal supervision completed 1-inch map; writes of his trips in the mountains, 2–8–52; "Having waited patiently for nearly 3 months since the earthquake (of May 1852) exposed the flank of Kunchinjinga, ... I started this morning at 8·30 a.m. accompanied by Mr. Robt. Smart ... Having just completed the survey of the British Hill Territory, and having had several very fatiguing trips in the hills, we were both in good walking trim [83, 186]. ...

8–8–52. "An hour and a half of sharp climbing carried us to the summit of Singaleelah where the Tumbok Pass leads from Sikkim into Nepal. Barometer gave an elevation of 10,792 feet. ... The Sirdar...[showed] us the cairn of stones erected by Captain C. T. H. Weston in 1822 [III, 513]".

Journal closes 19–8–52; "We reached Darjeeling having been away 18 days, during which we had travelled 360 miles on foot, ... reaching an elevation of 14,500 ft. distant in a direct line 17 miles from point of departure[2]".

Survrs. will sympathise with his note to Thuillier on the one-inch map on which he had been "working up the hills to distinguish the high from the low. ... It does not please me. I have looked at it too long and am tired of it".

Under GO. 13–12–53, handed over party to Gastrell 6–1–54, and deputed to special duty for "re-adjustment of district boundaries of Behar and Bengal", with allce. Rs. 200 pm.; Took up new duties at Patna 6–2–54, travelling round[3] to consult dist. officers, Comnrs., and judicial authorities. Writes to Thuillier, 17–3–54; "I am almost in despair with my work; I can make nothing of the million names that the Magistrate has given me. I suppose I shall find out soon what to do with them [255–7]"[3].

18–7–55, placed under orders of Comnr. Bhāgalpur during suppression of Santāl rebellion; "I at once placed myself under his orders, having...from the commencement...rendered every assistance I could, both to the Commssioner and to the military commanders by giving them information regarding the country, people, etc.

"Upon 25th July...I joined Major Shuckburgh's regiment, and proceeded...towards the Daman-i-Koh where up to the 6th August I was engaged as their only guide. ... Upon the 8th August...I joined Maj. Gen. Lloyd, C.B., at Rajmahal as his DAQMG.[4]".

"I was relieved of my duties...on the 14th inst. [Sept. 1855], when I proceeded at once to Berhampoor, where I am at present engaged closing my office prior to applying for leave on sick certificate to Europe. ... Having partially lost my memory, sight, and hearing, I am warned to stop work before it is too late"[5].

Furl. from Oct. 1855; resumed duty as Bdy. Comnr. from 30–8–56, making hdqrs. at Dum Dum and, from 22–11–56, appd. Prof. of Survg. at Civ. Engrg. Coll., Sibpur, in addition to other duties [397].

Oct. to Dec. 1859, acted as DSG. during Thuillier's absence up-country [349]; 1860, took furl. on mc. till ret. 31–12–61 [521].

Thuillier write of him, 18–12–59; "He is second to none as a draftsman, or as an administrator in charge of extensive establishments, his temper and judgement being above all praise, rendering it a delight...to serve either with or under him. ...

"He has also rendered valuable aid to Government as a pioneer geologist, ... and his statistical and geographical published reports and scientific papers in the Asiatic Journal prove his unwearied industry, energy, and talent [10, 397, 400]"[6].

Keen geologist and responsible for several valuable geol. maps [142]; Thuillier writes, 5–4–56, of his "excellent reports on Bhagalpoor and the Rajmahal Hills, Beerboom, and Darjeeling districts. ... published by the Board of Revenue. ... The pages of the Asiatic Society's Journal have likewise been enriched by this officer's various contributions on the physical geography and geology. ...

"A valuable guide map to the geological formations...was compiled by this officer, and published in December 1852"[7].

SHORTREDE, Robert [III, 502; IV, 465–7]. Bo. Inf.

b. 19–7–01. d. 26–11–68.

Ens. 4–1–23 ... Lt.-Col. 12–10–57; ret. as Hon. M. Gen. 31–12–61.

Son of Robert Shortreed, Sheriff substitute, co. Roxburgh

ed. Jedburgh gr. sch. and Edinburgh High Sch.; spells his own name as here given [III, 502].

m., Allahābād, 19–1–44, Clara Ann, dau. of Geo. Channer, of Sutton, nr. Hounslow, and sis. of Col. G. G. Channer (1811–95), Ben. Art., and Commy. of Ord. Allahābād, 1849–58; Hodson, I (329–30).

FRAS. 1848.

JASB., VI, 1842 (28, 40, 267); XXII, 1853, Msthl. Papers; *Log. Tables*, 1844 [IV, 467; V, 173–4]; *Traverse Tables*.

[1] DLR. 37/57 (143, 181); with sketch of cairn. [2] *JASB.*, XXII (541–637). [3] DLR. 37/68 (5), 17–3–54. [4] Maj. H. A. Shuckburgh (1800–60); Ben. Inf.; Hodson, IV (85–6); M. Gen. G. W. M. Lloyd (1789–1865), Ben. Inf., comdg., Dinapore from 10–11–54; Hodson, III (65–6). [5] DLR. 37/69 (146–8), to DSG. 1–9 & 17–9–55. [6] DDR. 668 (249). [7] DDR. 624 (26), DSG. to SG; *IO Cat.* (172–3), Bhāgalpur & Monghyr dists. with geol. infn.

1864; *Trans. RAS.* 1845, *Him. Attrn.*; ob. notice, *RAS.* (*mn*), XXIX, 1868 (120–1).

1824, Deccan topo. svy.; 1828, Bo. trgn.; 1832, to orders of SG.; 1834–6, on local rev. svy.] IV, 236]; 1836, resd. trig. svy. after disputes with Everest [IV, 73; V, 101, 122], but after apology took ch. of svy. during Jacob's absence [IV, 74, 359]; 23–9–39, appd. 1st. Asst. GTS., joining Everest's camp at Sironj 20–11–40 [IV, 357; V, 382].

1–9–41, took ch. Karara ser., making recess qrs. at Allahābād; progress slow and Everest far from satisfied [IV, 69–70; V, XI, 11, 155–6, 361, 368, 501].

Within two weeks of taking over as SG., Waugh wrote friendly letter asking Shortrede to speed up progress, and Shortrede, writing a few weeks after his marriage, promised to do his best[1]. In letter of 20th March 1844, however, replying to technical criticisms based on a report by Renny [101, 522], Shortrede wrote most disrespectfully of Everest, which drew sharp rebuke from SG.—

"If you had done twice as much work...you would not have escaped censure from my predecessor, because your work was...in direct violation of the positive instructions... furnished for your guidance, but...to address such aspersion to his successor is an act of the greatest discourtesy. ...

"My predecessor's letter...contains a distinct prohibition of any innovations [114–5]".

Shortrede was prompt in disavowing any intention to give offence, withdrew the offending letter which is not now on the files, and promised to meet the SG.'s wishes[2].

Towards the close of recess Waugh called for a regr. of angles obsd. with detailed report on the work completed. After examining these he decided that Shortrede's work was not good enough, and asked for his return to Bombay; "Captain Shortrede proceeded upon no regular method and... made no proper disposition of work among his sub-assistants [IV, 466]".

After criticism of Shortrede's lack of planning, and the wretched progress made, Waugh notes that "up to this date the computations have not been brought up, the whole of the work for two years remaining still in arrears. The angles taken in 1842/43 have, however, been submitted, together with a rough calculation. ... With one exception the work has not been executed in accordance with the established rules of the Department, which were furnished to Captain Shortrede. ... A great deal of unnecessary work has been done, and time and money have...been wasted [390–2]. ...

"From all I have learned of Captain Shortrede, he is a gentleman of undoubted talent and considerable mathematical acquirement. ... He has never, from the commencement of his career, followed a fixed system or concentrated the whole of his energies upon the sole object of speedily completing his work. ... The Karara Series will never make any decided progress...so long as the executive duties are entrusted to an officer who has never yet accomplished any great undertaking in this Department. ...

"He possesses...considerable accomplishment in the native languages, especially Mahratta. ... He has also served in the Revenue Department as an Assistant Collector, and has been employed in the Bombay Mint" [IV, 465][3].

Govt. accepted SG.'s recdn. and under GO. 57 of 14–2–45 Shortrede handed over ch. of Karara ser. 6–3–45, and proceeded on furl. from Bombay [336, 379, 390–2, 399].

Whilst in Calcutta after handing over he pursued his study of the deflection of the plumb-line that he had obsd. at Debra Dūn in 1841. He wrote direct to Govt. of India claiming that his results entirely vitiated the accuracy of Everest's work on the Gt. Arc [IV, 105, 466; V, 133–6].

These were passed to SG. for comment and Waugh replied that all the facts had been fully known to Everest. He rejected Shortrede's conclusions. The corr. was passed to the Directors who fully accepted Waugh's views. They regretted that Shortrede had not put the matter up before, and suggested "his late removal from the Department...[as] an inducing cause to his bringing the subject before you"[4].

Whilst in England Shortrede read a paper before RAS. 18–6–48, which was communicated to AR., Airy, who thought it "an ingenious and interesting investigation". He suggested a minor alteration which Shortrede gladly accepted [135].

On return from furl. Shortrede joined his regt. and, 8–1–50, sent copy of his RAS. address to Govt. from Belgaum, repeating his charges that Everest had glossed over discrepancies and deceived both Govt. and the scientific world [135]. Waugh passed this to Chief Compr., who agreed that the obsns. which SG. proposed to make at Banog would clear up the matter, and that Shortrede's obsns. at Debra Dūn would then be of small importance [135].

There is no doubt that Shortrede's persistent pushing of his views on Himālayan Attraction stimulated Waugh's interest in the subject, and led in turn to Pratt's investigations and theories which attracted world-wide attention [136–7, 520, 541].

20–2–51, appd. to succ. Stephen in ch. of cis-Sutlej rev. svy. and to move party to upper Rechna *doāb*, covering dists. of Gurdāspur and Siālkot. Moved in 1853 to Jech *doāb* to complete Gujrāt and Shāhpur dists. by end of season 1854–5; then moved into the Sind-Sāgar *doāb* beyond the Jhelum [7, 52, 218, 270, 273–4, 285, 364, 396, 400].

During this period he urged correct adjustment of convergence of meridian. The problem was referred to Debra Dūn, and definite deptl. orders issued on the subject [298].

In 1855 SG. put forward his name as officer of Bombay est. for ch. of rev. svy. of Sind. Shortrede objected strongly; "It is a matter of indifference whether the officer belong to Bengal or to Bombay, but...he should be young and active, and of from 10 to 15 years standing. ... and...likely to remain long enough to give the survey a fair footing. ...

"I have been now upward of 32 years in the service, of which I have been 27 hot seasons in the low country, and have served upward of 28 years in India, even deducting...leave of every sort. ... I am somewhat advanced in life, but my constitution is unbroken, and I am still active, and in my present locality may be efficient for several years to come. ...

"For some time past I have been intending for family reasons to go home on leave for a short period. ... If I should go to Sind...several years must elapse before...[the party] could be in good working order".

He pointed to the good work done by his party under his management during the past four years; "The only stimulus I have used has been my own example, and a fair acknowledgement of the merits of every man. ... Excepting myself there is not a man...who can say that he is hard worked. ... It can scarcely be for the advantage of Government that such an establishment should be broken up and dispersed as it must be if I go to Sind. ...

"I am the oldest surveyor in India, and...it would be nothing unusual to allow me, as such, a choice of locality, but this sudden removal against the known wishes of the local Government...is...a severe hardship" [45[2], 54[2]][5].

Unfortunately, he made a spiteful reference to his removal from the GTS. ten years earlier, in which he suggested that

[1] DDn. 491 (6–7), from SG., 1–1–44; 521 (57), Shortrede's reply, 14–2–44. [2] DDn. 491 (43–6, 54), from SG's. 18–5 & 15–6–44; 520 (57), from Shortrede, 5–6–44. [3] DDn. 452 (197–207), 7–12–44. [4] CD. to B., 14–1–46 (5). [5] DDn. 541 (110), Airy to PRAS. [6] DDn. 661 (115), to DSG., 18–9–55.

both Everest and Waugh had acted with personal bias against him. Thuillier passed this privately to the SG., who ordered that this suggestion should be withdrawn with adequate apology. He recapitulated the reasons for which he had considered Shortrede quite unsuited for the GTS.

Under Thuillier's tactful handling, Shortrede withdrew the offending passage "to avoid the re-agitation of matters of 10 years standing on which we hold opposite opinions" [391][1].

The tr. to Sind did not take place [277] and under GO. GG. of 17–10–56, Shortrede was placed under orders of C-in-C. for empt. with his mil. unit *en route* for Persia [194]. He handed over ch. of his svy. party to Anderson at Murree 12–11–56, and resumed ch. in Nov. 1857 for two months before leaving India 1859.

After rett. settled at Blackheath to work on his "*Traverse Tables*", which were pub. in London, Oct. 1863, and by Blackwood, Edinburgh, 1864.

The caption to his box of insts. now on exhibit at Svy. Museum, Dehra Dūn [IV, 467], wrongly suggests that Everest's Logarithm Lodge at The Park in Mussoorie had some connection with Shortrede [IV, 440].

SIMMS, Frederick Walter. Civ. Engr.
b. 24–12–03. d. 27–2–65.

Civ. Asst. OS. Ireland; Astr. Asst. Greenwich Obsy. to 1835; Asst. Engr. SE. Ry. 1836–45; under HEIC. to India as Cons. Engr. to Govt. & Dir. Rlwy. Dept. 1845–51.

Son of James Simms, senr., of Islington, and bro. to Wm. [1793–1860], partner to Edw. Troughton (1753–1835) from 1826 and sole proprietor of business from 1831 [IV, 491].

Telford Medal, 1842; MICE.; FOS.; FRAS.

DNB.; *RAS.* (*mn*), XXVI, 1866 (120–1).

Of delicate constitution; health partly restored on OS. in Ireland; 1835, resd. from Greenwich Obsy.; visited France, and asstd. introduction of asphalte to England; 1836–45, on construction of tunnels, etc., on SE. Ry.

1845, emp. at Calcutta by HEIC. as Cons. Engr. for Rlwys. to Govt. of India [322, 419]; sick leave to Mauritius; 1847–9, in ch. svy. and levelling Calcutta city [70–1, 181–2, 249–50]; *Ben. P & P.*, LII/II (104); 1936 (131) with section from map. Report on svy. dated 14–8–50, Calcutta (Simms).

1851, took home copies of map for CD., from which John Walker engraved map on reduced scale [182–3].

Now seriously ill, lived in rett. Torrington Sq., London.

STEWART, Robert Crosse. HM. 84th Ft.
b. 15–3–25. d. 10–7–1913.
Ens. 25–10–42 ... 1856, tr. to Rifle Bde. ...
Bt.-Col. 25–7–74; ret. as M. Gen. 15–3–84.

Son of Maj. Archbd. Stewart, KH., of Rifle Bde. and his wife Eliza, dau. of Robt. Crosse of Barrachnie, Lanark.

ed. Elizabeth Coll., Guernsey.

m., 1860, Fanny, dau. of Capt. T. Davidson of Sedgefield, Durham.

GB., 1881. *Who Was Who.*

12–9–54, appd. Asst., Pegu Svy., making report on Toungoo Dist. [196, 400] 8–5–56, *FD. Sel.*, XX, Pegu; also empd. as Ex. Engr. and Asst., Tel. Dept.; 1856, exchanged to Rifle Bde. in England.

Returned to India 1857 with HM. 35th Ft. (Royal Sussex); wounded at Lucknow. Successful mil. career.

STEWART, William Jackson. Ben. Art. & sc.
b. 22–12–37. d. 25–2–85.
2/Lt. 12–6–57 ... to BSC. 24–8–65; Maj. 37th BNI., 12–6–77.

ed. Addiscombe.

8–10–60, appd. Asst. Rev. Survr. No. 4 Div., Bākarganj; "a most accomplished draughtsman [256]"; in ch. from 2–9–62; *IO Cat.* (172); svy. Bhāgalpur town, 1867–8.

[1] DDn. 662 (3, 28), to DSG., 26–12–55 & 14–1–56.

In ch. various rev. svys. LF. to 1872; NWF. from 1873; resd. before 1877 [400].

ST. GEORGE, Richard de Lautour. Ben. Art.
b. 2–4–37. d., unm. Landour, 14–10–61.
2/Lt. 13–6–56; Lieut. 27–4–58.

eld. son of Sir Theophilus John St. George (d. 27–7–57) 3rd. Bart., and Caroline Georgiana, dau. of Joseph de Lautour of Hexton Ho., Herts.; succ. as 4th Bart. July 1857.

Burke (p. 1920).

8–10–60, appd. Asst. Rev. Survr., joining No. 2 Oudh Div. under Vanrenen for svy. Unao Dist. 24–10–60, dying of fever a year later [396, 400].

STRACHEY, Henry. Ben. Inf.
b. 24–2–16. d. 9–2–1912.
Ens. 12–6–35 ... Capt. 19–7–48;
ret. as Hon. Maj. 31–12–61.

2nd. son of Edward Strachey (1774–1832), BCS. and his wife Julia Woodburn, dau. of M. Gen. Wm. Kirkpatrick (1754–1812) [I: 344–5]; bro. to Richd. [*inf*] and Sir John (1823–1907), BCS.; GCSI. *DIB* [318 n.4].

ed. Addiscombe.

m., Cape GH., SA., 6–9–59, Joanna Catharine, dau. of Rudolph Cloete of Newlands, SA.

1851, Oriental Club; 1851, Patron's Medal, RGS., for svy. W. Tibet frontiers; auth. of several books & papers on Himālayan geography; keen botanist.

Burke 1956 (2079); Debrett, 1945 (969), sv. Baron Strachie; *JASB.*, XVII, July 1848 (98, 527–38); *GJ.*, XXXI, 1912 (405) Burrard & Hayden (239, 247); Mason (80–1), Sandes, II (230 n.1); *NF. Atlas* (11–12).

arrd. India Dec. 1835; on constrn. GT. Road to Allahābād, 1841–2; Kudubdia Lighthouse, Chittagong coast, 1844–5; 1846, sick leave to Kumaun; Sept. to Oct. visited Mānasarowar Lake, making sketches later compiled with those by his bro. Richd., MRIO. 25 (16); account with map, *JASB.* XVII, 1848; *JRGS.* XIX, 1849 (lxvii) [86, 147, 187, 324, 448, 528].

May 1847, with Dr. Thos. Thomson, attd. to Cunningham's mission to determine bdy. of Gulab Singh's dominions with Tibet; after exploring E. Ladākh [187 n.6], deputed to follow Indus R. from Leh to Gilgit; auth. *Physical Geography of Western Tibet*; *JRGS.* XXIII, 1853 [187, 240, 316–8].

Furl. 1851; and again 1861, sailing from Calcutta 23–7–61. Lost his sight about 13 y. before death but retained wonderful memory.

STRACHEY, Richard. Ben. Engrs.
b. 24–7–17. d. 12–2–1908.
2/Lt. 10–6–36, Bo. Engrs.; tr. to Ben. 25–9–39 ...
Lt.-Col. 2–7–60 ... ret. as Lt.-Gen. 23–2–75.

Bro. to Henry and John [*sup*].

ed. Addiscombe.

m., 1st., 1854, Caroline, dau. of Rev. Geo. Bowles; she d. 1855. 2nd., Calcutta, 4–1–59, Jane Maria, dau. of Sir John Peter Grant (1807–93), BCS., LG. Bengal 1859–62; *DIB.*

GSI. 1861; GCSI. 1897; FRS. 1854; Royal Medal, 1897; FRGS. 1887–9; LLD. (Camb), 1872; Council of India, 1875–8; 1879–89; auth. of art. *Himalaya, Ency Brit.* 11th edn.

Burke (2079); Debrett, 1945 (970), sv. Baron Strachie; *DIB.*; Conolly (89/192, 106/111); *Addiscombe* (491); Burrard & Hayden (142–3); Sandes, II (123–4, with portrait, 230, n.1); VM. exbt. 1039, portrait etched by Wrigman; *Who Was Who*; *JASB.* XVIII, 1849 (287–310); *Snow Line*; XIX, 1850 (79–82); *Niti Pass*; *QJGS.*, VII, 1851 (292–310), *Geology...Himalaya Mts. & Tibet*; Burkill, I (870).

1839–45, Jumna & Ganges canals; 1845–6, 1st. Sikh War; 10–2–47, surv'd. site battle of Sobraon, *IO Cat.* (236); 1847, sick leave to Naini Tāl, making bot. and geol.

excursions in Kumaun; Feb. 1848, services placed "at disposal of...Lieut.-Governor for...conducting scientific researches in Kumaun and its vicinity"[1].

During 1848 "made a journey into Tibet...botanising [and fixing] true position of the snowline, glaciers, geology, high passes into Tibet". Fixed position and height of "the sacred Kailas Parbat" with remarkable accuracy. The topo. svy. of 1871-2 found his position required "no material alterations" and height only 28 ft. too low [86, 147, 187-8, 318, 324, 448][2].

Hayden records that Strachey "laid the foundations of Himālayan stratigraphical geology" during his visit "to the Kumaun and Ngari Khorsum"[3].

Later had distinguished career, mostly PWD. and Rlwys.; during 1857 was Sec. to Sir J. P. Grant when LG. of OP. whose dau. he m. in 1859 [534].

STRANGE, Alexander. Mad. Cav.
b. 27-4-18. d. 9-3-76.

Corn. 22-6-34 .... Maj., Bt. 20-6-54; Regtl. 21-12-59; ret. as Hon. Lt.-Col. 21-12-61.

Son of Sir Thos. Lumisden Strange (1756-1841), Ch. Justice, Madras 1800, *DNB.*, and Louisa his 2nd. wife, dau. of Sir Wm. Burroughs, Bart.; g. son of Sir Robt. Strange (1721-92), distinguished engvr., *DNB.*

ed. Harrow.

m., Landour, 17-10-48, Adelaide Bruce, dau. of Wm. Davies, of co. Monmouth.

FRS. 1864; Council 1867-9; FRAS. 1861 Council & For. Sec, 1863-73; FRGS. 1861; judged at exbns. of London, 1862, and Paris, 1867.

DNB.; *DIB.*; *RAS.* (*mn*), XXXVII, 1876 (154-9); Markham (108-10, 114-5, 200-6); *JRGS.* 46 (cxlix); Condon (282-3); portrait, after rett. [pl. 22].

JASB. XVI, 1847 (1265-6); 1847, whilst on leave from regt., 7th Mad. LC., worked in Boileau's magnetic obsy. [IV, 117-8] and displayed ingenuity in making small inst. for graduating scales [379-80, 392-3].

24-12-47, appd. 2nd. Asst. GTS., and posted to NW. Him. ser., under Du Vernet for instn., joining in fd., 7-3-48 [35].

Like other young officers ran into debt whilst in Simla; AG. wrote to SG. 6-9-50, calling attention to bill from "hotel-keepers at Simla" for "the large sum of Company's rupees 304-1-2...contracted at their hotel in 1847. ... Sir Charles Napier desires you will communicate to him [Strange] his displeasure at the...impropriety of his conduct in neglecting to liquidate for so long a period the bill in question"[4].

Sept. 1848, posted to Gt. Longl. ser. under Renny, reaching Sironj from Dehra in mid-Nov. [523]. Before the start Strange had made up new friction rollers for TS. 3-ft. theodolite [150] and also for one of the 24-inch [153][5], besides getting married [361].

6-9-49, took over ch. of party from Renny at Nimach, and carried longl. ser. through to Karāchi during the next 4 seasons, across Aravalli Hills and "little desert". Promoted to 1st. Asst. 1-1-50, SG. being well pleased with results of his 1st. season; "This officer was originally selected...on account of his qualifications as an astronomical observer, as well as practical mechanic. ... The result has proved how well fitted he is to conduct...the survey with credit to himself and advantage to his employers"[6] [120, 137].

Not only was he a first-class obsr. and practical geodesist, with exceptional energy and drive, but he was also a formidable wielder of the pen, and became a great trial to SG. by lengthy letters describing difficulties he was overcoming, and pressing for extra staff and allowances [345, 362]. Waugh admitted his abilities, but explained in equally lengthy letters that it was impossible to meet his requests, though he was able in 1851 to post James Tennant to the party [38-41, 65, 99-100, 115-7, 362, 366-7, 383, 453, 533-4].

On Strange's report, 9-7-53, of the successful closing at Karāchi, SG. sent him warm congratulations "on this great achievement and on the brilliant manner in which it has been effected, challenging, as it does, the admiration and emulation of the Department. I have not failed to bring prominently to notice...your scientific labours, as well as the conduct of your assistants"[7] [2, 74, 130, 132, 194, 394].

Called to join in meast. of base-line nr. Attock, handed over to Tennant and reported to SG.[8] 24-10-53, that "I have this day taken my departure from Kurrachee by S.C. steamer 'Jhelum' for Mooltan, which station I expect to reach about the 12th November, and...thence by palanquin dak via Lahore to Attok, and...join your camp at the latter place about 25th November"[9].

On completion of the meast. in Feb. 1854, Strange spent a few days measg. span for bridge across the Indus below Attock [43, 517], and then took boat down the river to Karāchi where he took over ch. of 2nd Hill ser., Logan's old party which Kinlan had marched down from Lahore [43, 371]. Made all preparations for meast. of Karāchi base-line which he carried out to SG.'s entire satisfaction during the following Dec. and Jan., Waugh being unable to take active part owing to ill health [43-4, 158, 341].

22-9-54, whilst at Karāchi, appd. Astr. Asst. in succn. to Renny-Tailyour [380-1], and during 1855 emp. at Dehra Dūn where he gave instn. to junior sub-assts. on care and use of insts. and other technical subjects [138, 157, 163, 343, 410].

2-7-55, in view of expected rett. of Peyton, SG. warned Strange for ch. of East Coast ser.; "No marching equipment or adequate carriage can be procured on the spot. It will, therefore, be incumbent on you to fit yourself efficiently for the field and take your equipment with you. Leaving Dehra on the 1st. October, ... you will reach Cuttack in time to join the party before taking the field, so that with the 3 months notice now given you to prepare", no difficulty or delay need occur'. ...

"The very great importance of this Series which unites the capitals of Bengal and Madras, and connects the two observatories, ... will require corresponding exertions and zealous devotion...to achieve satisfactory success"[10].

In a letter of 82 paras he referred to the serious obstacles of climate and terrain that had interfered with progress, and hoped that "your first season in charge of the Coast series may be signalized by a triumphant success worthy of your standing in the Department"[11] [27-8, 71-2].

On march down Strange spent a week examining the insts. of the old Lucknow obsy.; he found them still in good order, and it is sad that they should all have been destroyed during the disasters of 1857 [IV, 116-7; V, 534][12].

SG. took advantage of Strange recessing at Cuttack by directing him to exercise general control of Depree's party during Sarton's absence on furl., at the same time explaining to Depree that he had no wish to reflect on his efficiency. "I do not doubt that your own good sense would have induced you...to profit as much as practicable by Major Strange's experience. ... Major Strange has not at present any practical

[1] DDn. 472 (379), Thomason, Sec. to Govt. NWP., to SG., 14-2-48. [2] *GR. Trig. 1871-2*, ht. Kailas 22,028; Burrard & Hayden (6, 92). [3] ib. (298-9, 343, 348). [4] DDn. 541 (232-3). [5] DDn. 462 (265-307), SG. to Mil. Dept., 15-1-49 (para 40. [6] DDn. 542 (37), to Mil. Dept., 20-8-50. [7] DDn. 591 (330), 29-7-53. [8] DDn. 710 (4). [9] Du Vernet had complained of lack of notice on tr. to Assam in 1852 [393]. [10] DDn. 592 (216), 2-7-55; DO., 26-9-55. [11] ib. (375), 1-12-55. [12] Waugh MSS., II (xii).

knowledge of detail surveying, nor has he indeed been trained as a surveyor, but his experience in geodetic operations and all the refinements of our profession will enable him to give you valuable advice"[1].

The arrangement worked well and Strange gave SG. a most satisfactory account of Depree's party [172, 386, 496].

Unfortunately Strange's first season with the Coast ser. was not a happy one. Conditions were as different as possible from those in Rājputāna and Sind. He lost much time trying to adjust the ways of the party to his own ideas, and wrote long complaints to SG. Time was spent in re-obsn. at several stations ; work was hampered by wretched visibility ; there was much sickness amongst all ranks. Waugh was not impressed [28, 109, 112].

Next season was better, but Strange himself went down with fever and in Aug. 1857 he handed over to Clarkson and went on 12 mo. sick leave to Ootacamund [465–6]. Whilst on leave he worked on design of a new 3-ft. theodolite [151–2].

The 24-inch theodolite with Coast ser. had been giving trouble, and at Strange's request four men from the Calcutta workshop carried out alterations under his supervision at Cuttack ; "The project...involves mechanical work of a very high order, and is...a very arduous and anxious undertaking. Major Strange is himself a first rate workman, but he has so much other occupation...that it is not desirable that his time should be wasted in the mechanical drudgery"[2].

The alterations made during 1856 had to be supplemented with further work the following year, but the results were most disappointing and, writes Waugh two years later, "the instrument has worked worse than ever since Major Strange altered it, and its results are now so altogether unreliable that I have been compelled to withdraw it from the Coast Series". ... Major Strange's mechanical talents, ... although of a high order, are limited by his deficiency in mathematical knowledge"[3] [30, 154].

Work on the new 3-ft. theodolite was much interrupted by his long illness, and constant changes of detail, and it was not until Aug. 1860 that he handed in the drawings and specification which he then took with him to England in Nov. 1860. Construction was entrusted to Simms, but when Walker inspected it in 1872 he thought it far too heavy and cumbersome for use in India[4]. It was, however, sent out and was used in Dec. 1874 on obsns. of transit of Venus, and in 1882 was passed to the Capetown Obsy. [151–2].

Strange resumed ch. of the Coast ser. in Aug. 1859, and on promotion to regtl. Maj. he offered to revert to mil. duty or stay on with the GTS. as the SG. might wish. In 1851, SG. had obtained permission for his retention with the Dept. at a time when he was particularly short of officers. He now expressed his readiness to release him, since he had secured several young officers of higher qualifications [382].

Under GO. GG. 21–3–60 Strange's services were placed at disposal of the Madras Govt. He handed over ch. of Coast ser. 9–8–60, and sailed from Calcutta for Madras 3 mo. later [399].

In 1862, after rett. he was emp. to design and suptd. construction of insts. of all descriptions for GTS. and in 1863 was appd. Inspr. of Scientific Insts. to the IO., for which duty a special obsy. was erected in Lambeth[5]. 28–2–67, he exbtd. to RS. a transit-inst. and a zenith-sector.

His first zenith-sector was used by Herschel in S. India, 1869–71, and greatly appreciated, but writes, Burrard, "In 1885–86, I had to observe latitudes with Strange's zenith-sector, and found it a hateful instrument, with 8 difficult microscopes to read for every observation. It damaged my eyes for life. ... Some years later...I realized that Strange's zenith sectors could be used as...telescopes. I observed two seasons in Rajputana and Sind...and treated them as zenith telescopes. This avoided all the reading of the numerous microscopes, and produced better results[6].

Lenox-Conyngham writes that they "were fine instruments, but awfully heavy. ... I used one of them in season 1898–99 for the determination of latitudes...round Kalianpur"[7].

Strange's work as Inspector of Instruments was of immense value and importance, and the procedure which he introduced for supply of scientific insts. to India put the whole organization into an efficient state[8]. Markham's successor, Black, writes 24–12–75 ; "tardy recognition has been shewn to him by giving him...a provisional...post of £500 a year. But Col. Thuillier...had to speak strongly on the subject at an interview he had with Lord Salisbury"[9] [10].

TAVERNER, Edmund Lewin. Bo. Inf. & SC.
bapt. 29–10–28. d. 21–12–91.

Ens. 17–1–46 ... Maj. 17–1–66; ret. as M. Gen. 1–8–78.

Son of Edmund Taverner, solicitor, Stoke Newington, and Elizabeth his wife.

m., 8–9–64, Mary, dau. of Lt. Herbert Mackworth, RN; High Sheriff of Trinidad, WI.

30–10–53, appd. Asst. Rev. Survr. ; 1860, Asst., Thāna Rev. Svy. ; 1862, Settmt. Offr. Hdbd. Sind ; Markham (450), 1876, Supt. Rev. Svy. & Assmt., Poona, Sholāpur & Nāsik ; 1877, on furl [338, 401].

TENNANT, James Francis. Ben. Engrs.
b. Calcutta, 10–1–29. d. 6–3–1915.

2/Lt. 11–6–47 ... Lt.-Col. RE. 1–7–70 ... furl. 6–2–81 ; M. Gen. 26–5–83 ; ret. as Lt.-Gen. 10–1–84.

Son of Brig. Sir James Tennant (1789–1854), Ben. Art. EOB. ; *DNB.* ; *DIB.* ; *Hodson*, IV (246–7) ; *Punjab Inscr.* (359–40) ; and his wife Elizabeth Louisa, dau. of Chas. Pattenson, BCS.

ed. privately & at Addiscombe, 1846–7 ; "distinguished in maths.".

m., 1st., Deesa, Rājputana, 11–8–52 Augusta, dau. of Wm. Fleming Dick, BCS., by whom he had 3 sons and 1 dau. ; she d. in childbirth, Mussoorie, 23–6–59, aged 30.

m., 2nd., in England, 1867, Miss Selina Tudor Crawford who d. 1878 ; one of 3 daus., Edith Marian, d., Malvern Link 23–2–1960, aged 87.

FRGS., 1859 ; FRS., 1869 ; FRAS., 8–6–55 ; FRAS. 1890–1 ; CIE. 1879.

Ubique ; Conolly (91/254) ; *RAS.* (*mn*), LXXVI, 1916 (272–6) ; *Who Was Who* ; crayon portrait with RAS. ; photo. [*pl.* 22] ; Sandes, I (330–1, 360) ; II (211, 207–8, 317 n.3).

arrd. Calcutta March 1849 ; emp. on canals under Cautley ; recdd. by SG. for appt. to GTS. " one of the best mathematicians in India, and devotes his leisure to...astronomy. ... His heart is...set on distinguishing himself as a geodesist"[10].

GO. 24–10–51, appd. 2nd. Asst. GTS. ; joined at Dehra Dūn 10–11–51, and posted to Gt. Longl. ser. under Strange, joining at Abu March 1852 [41, 383, 532]. 1853, prepared site for Kārachi base-line, "having had considerable experience of levelling" [42–3].

[1] DDn. 691 (33), 10–4–56 ; 578 (13), DO., 9–4–56. [2] DDn. 665 (192), SG. to DSG., 14–4–56. [3] DDn. 157 (14), SG. to Tennant, 25–5–59 ; 594 (361), to Mil. Dept., 6–10–60 (para 35). [4] Strange showed it to RS., 2–5–72 ; *Nature*, 25–4–72 ; 497 (509). [5] Paper by Strange to RS. ; *Nature*, 25–4–72 (497) ; Eur. Letters, II (120) ; GTS., XI (frpce). [6] to RHF., 6–5–1935. [7] ib. 5–4–1954. [8] Markham (200–6) ; *Abstract*, 1871–2 (21–4). [9] Eur. Letters, II (120). [10] DDn. 542 (250), to Mil. Dept., 28–8–51.

Took over ch. Gt. Longl. from Strange 22–10–53, party now becoming Gt. Indus ser. [3, 42, 361]; erected obsy. at Karāchi and took obsns. for lat. and sea-level [74–5, 91, 130–1, 470]. Took part in meast. of base-line, Nov. 1854 to Jan. 1855 [44].

1853–4, obsd. first 15 triangles of Gt. Indus ser. running 90 m. across hills N. of Karāchi [45].

After inspecting his work at Karāchi, SG. much impressed by his ability and the progress made; "I wish first to thank you for several valuable suggestions and discussions, ... which evince sound knowledge of mathematical principles as well as much ingenuity and talent. ...

"I have found you...a sound thinker and, as your opinions are always expressed candidly, and your objections stated clearly, ... I have had great pleasure in transacting business with you. I hope...you will always state your views and wishes to me freely. ... After a careful inspection of your angle-books I have formed a favourable opinion of your skill as an observer" [116 n.3, 136][1].

Nov. 1855, left Karāchi by road following the Indus and resumed work on main triangles [100, 109–10, 151, 367]. Made excellent progress across the flat country west of Indus up to lat. of Sukkur. Handed over to Armstrong, and marched direct to Dehra, 5th April to 21st May. Armstrong followed with the party to reach Dehra by end of June, when Tennant resumed ch. [46, 361, 370].

Season 1856–7, switched party to Jogi-Tila ser., which he extended S. from Lyallpur across Rāvi towards the Bahāwalpur border. Returned to Dehra shortly before outbreak of mutiny, May 1857 [47, 53, 150, 482]. At Dehra had no time to complete comps. and reports of the past season's work, but eased local difficulties by suggesting issue of paper money during the emergency [95, 483, 520].

Aug. 1857 joined the army at Delhi, the CE. then making official appn. *for his services*[2]. SG. gladly consented; "Lieutenant Tennant, having received private intimation that his services would be required, ... and having obtained from me leave to proceed in anticipation of orders, left...on the 15th to join the Army. ... If my Department can in any way aid...the public service, ... we shall all...have great satisfaction in doing so"[3].

Attd. to the 4th col. that entered Delhi by Lahore (or Kābul) Gate during assault of 12th Sept. He then acod. Engrs. to relief of Lucknow, reporting death of Brownlow [483, 493], and destruction of the astr. insts. [IV, 117; V, 532]. Being no longer fit for "active duty with the Engineer Department", rejoined at Dehra in April 1858 [138, 291].

4–10–58, appd. to ch. Gurhagarh ser., starting nr. Siālkot. After disappointing season, with interruption from unseasonable rain, closed work at end of April [50–1, 297].

Nov. 1857, had applied for appt. as Astr. at Madras Obsy., should post fall vacant. SG. strongly recdd. him; as his "pretensions are of a high order. From his father... he inherits a natural talent for mathematical studies and pursuits, which his father caused to be early fostered, and... he is now second to no mathematician in this Department. ...

"As an astronomical observer he has had abundant opportunity of proving his ability. ... He has sedulously... devoted all his leisure hours and spare cash to the cultivation of astronomical science. ... As a mechanic, ...especially...of astronomical and geodetical instruments [154], Lieut. Tennant is not only practically proficient, but possesses an inventive genius of a high order. ... Astronomical science is his peculiar delight"[4].

SSI. 9–3–59, appd. Astr., Madras, in succn. to W. S. Jacob [IV, 448–9], but obtained permission to postpone move till 1st Oct., when he hoped "to travel with his family". The birth of a dau. on 23rd. June was accompanied by tragic death of his wife on same day. Took over at Madras 13–10–59, but relieved by Norman Pogson, Oct. 1860 [380].

On his leaving the GTS. Waugh thanked him for his work; "the determination of the latitude of Karāchi; ... the tidal observations at Manora; your assistance in the measurement of the Karāchi base-line; and conduct of the lower section of the Great Indus series[5]" [399].

From 1860 to 1876, served with PWD. from Akyab to Rājputāna, with breaks for furl., for obsns. of eclipses and transits, and acting as Mint Master. He did not enjoy the dull PWD. routine, and his health was far from good. He writes to Walker whilst on furl. in 1866; "My sentiments about India are unchanged, but I must come out again. I could live myself on no great sum, but schools are simply ruination. ... I don't feel good for much, and all the patching that can be done at home will soon wear off in India. I wish I could get *quit* of that...PWD. Department. India would be bearable with decent work, even with bad health aggravated by remedies"[6].

Three years later he writes from Multān discussing the metric system. "Strachey [Richd., 531–2] is hot on Government Departments using the metre, and I only doubt if they will. The DPW. knows a 6-inch hinge, and they wont readily call it 15 centimeters, even for Govt. orders. Indeed the Govt. of India have really lost all authority as they have yielded to the Local Govts. till they are powerless to compel obedience. ...

"All the arrangements for a metrical system...should be made under one superintendence if possible. ... I have applied for a transfer from this province"[7].

And again four years later, writing on an astr. problem; "I am nearly crazy with this PWD. ... I hope you can make it out without a figure, for it is too hot to think about how to draw it. ... I have no brains for this incessant worry in such a temperature too"[8].

Possibly influenced by uncongenial work, bad health, and hot weather, his letters frequently had a bitter note. He writes critically, and unkindly, of Everest, Waugh, and Pogson [*sup.*, 542]. Though his obit. notice on Everest was fully appreciative[9] he writes to Walker, 24–4–68; "Everest had many good points. He picked up a practical truth very often and held it tenaciously, but...he never was a mathematician except as an elaborator of formulæ. ... I wanted to acknowledge the debt we owed. ... We may not agree with Everest, and we may think him opiniated. ... His aversion to enter on any matter on which he had made up his mind I can well understand [134 n.1]". Tennant had never worked under Everest, and was nearly 40 y. his junior. As Lenox-Conyngham writes[9]; "It is very probable that Tennant was a better mathematician than Everest. But...Everest had a very sufficient command...to be able to do whatever he wanted to do. ... 'The mere mathematician' is not the man who is wanted for geodetic operations".

Tennant justifies what he calls his "hole-picking" on the grounds that "one must place the good points of our forbears in relief". Burrard tells a story that illustrates Tennant's self-appreciation. Some great man was visiting Tennant who was engaged on recondite scientific work, and asked a simple question to shew his interest. Tennant made the churlish reply; "The fact of your asking such a question shows that it would be useless for me to give you an answer".

[1] DDn. 709 (113), Karāchi, 22–1–55. [2] DDn. 646 (96, 98), AAG. & CE. to SG., 20 & 25–8–57. [3] DDn. 645 (336), to AGG., 24–8–57; known in Engr. mess as "Objector-General", Sandes, I (330). [4] DDn. 643 (198), to Mil. Dept., 4–11–57. [5] DDn. 647 (46), 6–9–59. [6] Eur. Letters, I (85), 13–11–66. [7] ib. (88), 25–9 & 11–11–69; II (20, 22), 13 & 30–6–73. [8] *RAS.* (*mn*), XXVII (105–8). [9] to REF., 2–5–1954.

Undoubtedly the work in which he delighted was astr. obsn.; he called attention in Jan. 1867, to the importance of scientific obsn. of the solar eclipse of 17/8–8–68 and, on the advice of the AR., Govt. of India provided the funds, and Tennant took ch. of obsns. at a station nr. Guntur, with John Herschel as one of his assts. [492, 503]. Obsd. total eclipse 11/2–12–71 at Dodabetta nr. Ootacamund.

Again at Airy's request obsd. the transit of Venus from Roorkee, 29–9–74 [152]. The results and deductions from his work won the respect of the scientific societies.

It is strange that through all these high-class obsns. he suffered from a defect of eyesight. He writes, 15–10–68: "Many years ago, soon after I came to India, I found in looking at the snowy ranges of the Himaleh with a telescope, that to my eye the snow had a reddish-brown tint. ... This was not the same for both eyes, but...in passing from my right eye to my left...I seemed to pass...from the brownish tints of autumn to the brilliant ones of spring". His right eye was "not achromatic. ... Red rays predominate[1]".

From 18–1–76 to 6–2–82, was Master of the Mint at Calcutta, having already officiated for short periods. He then took furl. till ret. He took an active part in the affairs of the RAS., joining Council 1885, and being Presdt. 1890–1. Contributed some 50 papers to the pubns. of the Society.

After 1892 he contributed no more, but lived "in perfect retirement" with his daus. at 11 Clifton Gdns., Maida Vale. In 1890 he joined the Photographical Society.

THOMPSON, George Hunter. Ben. Inf. & SC.
b., Frederickton, New Brunswick, 25–10–26.
d. England, 11–1–95.
Ens. 8–12–43 ... BSC., 18–2–61 ... Bt Col. 8–12–74; ret. as M. Gen., 10–6–81.

Son of Capt. Arnold Thompson, Pymr. HM.'s 81st. Ft., of Frederickton, New Brunswick, and Anne Marie his wife; neph. of M Gen. Geo. Hunter (1784–1854), Ben. Inf., CB.; Hodson, II (504).

m. before 1850; son b. Berhampore, 17–10–52.

Ubique.

from March 1850, Ex. Engr. PWD., Wazirābād.

28–8–50, appd. Asst. Rev. Survr., Sherwill writing to DSG.; "Let me recommend to your notice young George Thompson of the 7th Infantry, a young fellow who has passed an examination in surveying in Sinde. ... A nephew of Major-General Hunter's, and his heir. The young fellow is dying of ennui and idleness at Ludhiana, and sighs for something to do. ... He has passed in the language. He is fond of drawing and surveying, is active and young; all good qualities for a surveyor"[2].

Leaving Siālkot, writes to DSG. from Meerut, 19–12–50; "When at Umballah, 14th Dec., Mrs. Thompson attacked by fever; lost one dak; delayed again, boats not being ready at the ghaut. Hope to start from Gourmucktesar on 25th"[3].

Again, from camp nr. Suri. "Sherwill started for the Rajmahal Hills on the 16th. ... In a few days I intend to accompany Mr. R. Smart on one of his rounds, and after closing a circuit, setting up the work and calculating the area, I hope...to become master of the greater part of the outdoor detail. We have exceedingly pleasant weather, and a little rain that fell a few days back has made it quite cold. ... I had no idea that the climate of Bengal could have been so very pleasant. ...

"I like my appointment very much, being a most agreeable change from my late duties"[4].

GO. 27–8–52, as senior asst., appd. to ch. Bari *doāb* rev. svy. in Punjab, succg. John Blagrave [273]; assumed ch. 22–10–52, and confirmed 29–3–53 [365].

1858–9, tr. with party to Chota Nāgpur. Left recess qrs., Simla, 1–12–58, by dak, and reached Hazāribāgh 25th, in advance of party which followed 2 mo. later. During first season the party made 4-inch svy. of Hazāribāgh town in addition to the regular svy., and survd. GT. road passing through the dist.; Thompson later supplied useful maps to Oldham, of the geol. svy. [184, 244, 364, 396–7].

In Dec. 1860, met C-in-C. at Hazāribāgh to arrange "a special survey with plan and report of the capabilities of the site as a sanatarium of the hill called Lugoo, appertaining to the...Ramgurh estate, about 25 miles south-east of Hazāribāgh on the road to Calcutta"[5].

2–11–66, handed over ch. to Sconce, and proceeded on furl. on mc.; to mil. duty on return [400].

THOMPSON, Penton. Ben. Art.
b. 21–6–34. d. 3–12–1917.
2/Lt. 8–6–54 ... Capt. 1–5–64;
tempy. ½-pay, 8–8–68; permt. ½-pay, 28–9–76.

Son of Geo. Powney Thompson (1797–1849), BCS., and his wife Harriet, dau. of John Fendall, BCS.

ed. Eton and Addiscombe.

m., Meerut, Sept. 1857, Emily, dau. of Lt.-Gen. Sir Wm. Sampson Whish (1787–1853), Ben. Art. [IV, 163 n.7].

1857, Mutiny campaign; at siege of Delhi with HA. battery; relates that after capture "Hodson came into our mess and asked if anyone wanted to go to Meerut, as he had a seat to spare. 'I do', I said, and I went, got married, and was back in a few days". His wife only lived 2 or 3 years.

6–10–58, appd. Asst. Rev. Survr., Sind Sāgar and with Anderson to Oudh [275]. Under GO. GG. 27–6–62, succd. to ch. 29–5–62; resd. 31–12–63 [400].

THOMSON, John Turnbull. Civ. Survr.
b., Glororum, nr. Bemborough, Northbd., 10–8–21.
d., Invercargill, Scotland, 16–10–84.

Rev. Survr., EIC., Singapore, 25–10–41; resd. Jan. 1855; Ch. Survr. Otago., NZ., 1856; SG., NZ., 1876; ret. 1879.

No record of any service in India.

g. son of James Thomson, of Earnslaw, Berwick; his mother was dau. of John Turnbull of Berwick.

ed. Dunse Academy; also Wooler and Marischal Coll. Aberdeen. m., in Otago, NZ., 1858, Miss Williamson.

FRGS. 1848; and artist of merit.

Auth. 1864, *Some glimpses of life in the Far East*; 1865, *Sequel.*; *RGS Progs.* VII (46).

Obit. *Southland Times*, NZ., 17–10–84; *New Zealand Times* 18–10–84; *RGS Progs.* IV, 1885 (86).

arrd. Singapore, 1837/8; appd. Rev. Survr., Singapore, 25–10–41; *IO. Cat.* (515, 608–9), maps of Perak R.; Singapore, town & straits 1846–55; Malay Coast, 1851; from 1847 under distant orders of DSG. Calcutta. [244 n.1, 536][6].

Aug. 1853 to Nov. 1854, sick leave to England; Jan. 1855 resd. on grounds of ill-health.

1855/6, arrd. NZ., as prospective settler, but, claiming 17 y. service with EIC., appd. Ch. Survr., Otago. Read paper before RGS., 10–5–58, being *Journal kept during...reconnaissance survey...Otago*, NZ., Jan. to April 1857. This was pub. *JRGS.* XXVIII (298–332), the following passage appearing pp. 327–8; extracts re-pub CXXIV, 1958 (534); after claiming several years service "on survey in India", and comparing life in the NZ. survey service very favourably with that "of India" he continues;

"The Indian Survey officer is clothed in white from 'sola topi' down to canvas pipe-clayed shoes. He smokes his perfumed 'hooka' or the fragrant 'manila' with an air of listless satisfaction. When he walks on duty he is followed

[1] *RAS.* (*mn*), XXIX, (105–6); Tennant, Calcutta, 15–10–68. [2] DLR. 37/57 (21), 5–3–50. [3] ib. (122). [4] ib. (146). [5] *Ben. Rev. LP.*, SG.'s 24–12–61. [6] MRIO. 110 (6–8); 4 and 1-inch maps Singapore Id. 1842–49.

by a 'piada' carrying an umbrella to shade him from the sun, and should a gutter cross his path two lusty 'bearers' are ready to lift him over.

"Two or three hours of outdoor exposure of his precious self suffice for the day, which done, he sits at the door of his spacious tent enjoying his 'otium cum dignitate' and his 'brandy pani'. The slightest weight distresses him—he does not even carry a purse. He has hundreds of luxuries at his command, but does he enjoy them? No—an extra mouthful of 'moorgee' or glass of 'simkim' requires three doses of nitro-muriatic acid to assist poor debilitated nature. His hollow eye and cadaverous complexion tell a tale".

His *Glimpses of Life in the Far East* gives no record of service in India. Vol. I describes Malaya and his approach through "the straits of Sunda", separating Java and Sumatra, 3 months after sailing from England, 1838/9. Vol. II, devotes 5 chapters to organization of the EIC., with "glimpses of the special and political state of my countrymen in India", but without any claim to have visited India.

Possibly he allowed himself to caricature a survr. of the EIC. working in Malaya?

THOMSON, Thomas. Ben. Med. & Botanist.

b. 4–12–17. d. 18–4–78.

Asst. Surg. 21–12–39; Surg. 1–12–53; Surg.-Maj. 21–12–59; ret. 25–9–63.

Son of Dr. Thos. Thomson (1773–1853), *FRS.*; *DIB.*

ed. Glasgow High Sch. and Univ.; studied botany under Sir Wm. Hooker; MD. Glasgow, 1839.

m., 1854, Catherine, dau. of R. C. Sconce, of Malta.

FRS. 1855; FLS.; FRGS., Gold Medal, 1866; auth. of *Western Himalaya & Tibet*; *Flora of British India* (one vol.); *JASB*; XXV, 1856 (405–18), paper or Herbarium at Calcutta Bot. Gdns.; Markham (369 n.2).

DNB.; *DIB.*; *JRGS.* XLVII, 1849, letters from Ladākh; Hooker; obit., *GJ.* XXII, 1878 (309–15), Burkill, II (78–9), 339–40; IV (344–5).

arrd. Calcutta 1840; Curator ASB. museum.

1840–2, Afghān expn.; taken prisoner at Ghāzni, lost all collections and possessions; escaped to join Pollock's col. [IV, 281].

1843–5, Morādābād; 1845–6, 1st Sikh War, Sutlej campaign.

1847, with Cunningham's mission to Ladākh; after visit to Upper Sutlej arrd. Leh Oct. 1847; traced Shyok R. to source; wintered at Skardo; to Srinagar April 1848 [531].

Returned to Leh via Kishtwar and visited Karakoram Pass, 19–8–48, claiming to be first European to do so; estimated height of range as from 20–21,000 ft. [89, 187, 240].

1849–50, on bot. research with Dr. J. D. Hooker in Sikkim, contributing to his map [186]; v. Hooker(238, 242).

Supt. Bot. Gdns. Sibpur, Calcutta, 1854 till ret. 1861, a confirmed invalid; Burkill, III (704).

THUILLIER, Henry Edward Landor [IV, 471]. Ben. Art.

b. 10–7–13 d. 6–5–1906

2/Lt. 14–2–32 .... "official" Maj. 7–5–56; Lt.-Col. 18–2–61; Gen. 1–7–81; Col. Comdt. RA., 1–1–83.

DSG. 13–4–49; SG. 12–3–61 to 31–12–77.

Son of John Pierre Thuillier, merch. of Cadiz and Bath, Baron de Malapert, France, and his wife Julie, dau. of James Burrow of Exeter.

ed. Addiscombe, 1831–2.

m., 1st., Calcutta, 21–12–35, Suzanne Elizabeth, dau. of Rev. J. H. Cardew, rector of Curry Malet, Somerset, and wid. of H. W. Steer of Bengal. She d., Calcutta, 7–1–44.

m., 2nd., Calcutta, 8–4–47, Annie Charlotte, dau. of Dr. G. Macpherson, Ben. Med.

His eld. son, Henry Ravenshaw (1838–1922) [537–8] and s. g. son Leslie Cardew (b. 1877) followed him in the Svy.

FRGS. 1859; FRS. 1869; CSI. 1872; Kt. Bach. 1879; auth. with Smyth of *Manual of Surveying in India*, Calcutta, 1851 [283–4, 338].

obit. *GJ.* XXVII, 1906 (367–8); *DNB.* 2nd Suppt.; *DIB.*; *Who Was Who*; Hodson, IV (273–4); Portraits; paintings in oil c. 1845 [IV, pl. 21]; photo in group, 1861 [517, pl. 20] photo-etching, 1864 [pl. 24]; oil painting by G. G. Palmer[1] c. 1875, printed deptly. 1915; large portrait in oils, 1896, with family, with RM. portraits, s. Kensington.

3–1–37, appd. Asst. Rev. Survr. in ch. svy. Jaintia *parganas* of Sylhet; promoted Rev. Survr. 25–7–39; ch. Cāchār, Puri, Patna, Sylhet, 1839–43 [IV, 185–6, 199–200, 207–8]. Three y. furl. on mo. 14–2–44, after wife's death.

Dec. 1846, reported to Art. depot, Dum Dum, on return; 5–2–47 posted to ch. 24-Parganas svy. vice W. A. Wilson, but held for ch. asst. Calcutta, offg. 9–2–47 as DSG. for Wroughton, sick[2]. On Smyth's taking ch. 24-Parganas, 22–6–47, tr. on paper to ch. Tirhut svy. for purposes of pay. Continued to offg. as DSG. during Wroughton's absence, and confirmed from 16–4–49, when Wroughton failed to resume duty [IV, 476; V, 348, 395–6].

SG. welcomed his appt.; "I never met with a better man of business, or one more zealous, punctual, and energetic in the discharge of his duties, of which he is thoroughly master. His views and mine on survey matters are entirely in unison, and he participates in my earnest desire to raise the character of the national survey of India by maintaining principles of accuracy and correctness, and introducing every proper improvement. ...

Considering...the extended sphere of his duties and responsibilities, the diginity of his situation, the expense of living in Calcutta, and the fact of several junior officers under his control being in receipt of larger allowances, ...I beg...the grant of the officiating staff salary of Rs. 688 per mensem to Lieut. Thuillier from the date of his receiving charge of the office" [398][3].

This acting allce. was duly sanctioned under Fin. Dept. of 22–1–48[4].

In addition to ch. of SGO. at Calcutta [70–1, 280 n.1, 348–9, 351–4]—Comp. & Drawing offices and Mathl. Irst. Workshop [153–4, 163–6, 238, 357–8]—Thuillier was Supt. Rev. Svys.; 6 svys. in progress in the LP., new svys. started in Rohilkhand and Rājputāna under NWP. Govt., and others in the Punjab under Bd. of Admin., Lahore [6–7, 183, 241–4, 258–72, 349–51]. He was also directed to supervise svys. started in Burma and Malaya [244, 349, 535].

Though DSG. was directly responsible for these rev. svys to the Rev. Bds. of the local Govts., SG. was the ultimate chief [338, 542], and Thuillier sends him "a copy of my operation report...which—though not entering into scientific details for...the Revenue Board—will, I trust, not be without interest to you, and if there are any suggestions which appear to you necessary, I shall be only too glad to attend to them. In such a wide sphere—from the Punjab to the Straits of Singapore [535]—it is not an easy task to supervise, or bring one uniform system...into force, but I trust with your...support to do some good before I vacate my seat"[5].

[1] Geo. Gidley Palmer from os. S'hampton; Engraving off. Calcutta, 1872–91; portraits of both Thuillier's, Walker, and Depree. One son, Alfred, also engvr., d. Calcutta, 4–5–88; another with Burma topo. party; he himself d. at Exeter. [2] signs as Offg. DSG., 8–1–47. [3] ½ staff sal. DSG. Rs. 425 & ½ rev. svy. allce. Rs. 263; DDn. 460 (240–2), to Mil. Dept., 6–12–47. [4] DDn. 472 (375–7). [5] ib. (369–72), 5–2–48.

In recdg. him for confirmation in 1849, Waugh acknowledged the "able and zealous co-operation he has always rendered me in the compilation of materials for the Atlas, more particularly in respect to the Revenue Survey districts, and the improvements he has introduced by my advice into the Revenue Surveys now in progress, all of which are most valuable, and stamp him as an officer of great merit [243, 283–4, 293, 298, 302, 305, 307–8, 338]"[1].

Thuillier now asked for special promotion to Major to support his official position; "There are no less than 9 commissioned officers at present employed under me in addition to 3 surveys in charge of uncovenanted assistants, and which may at any time be held by military officers. Of these two are altogether senior in the army, another though junior in the service has superseded me, and two more very young in the Department are likely to do the same. On a late occasion an officer holding the rank of Captain of longer standing than myself was nominated to officiate in the Department, and therefore, although perfectly new to his duties takes rank before me[2].

"The official rank of Major being given to the Deputy of almost every other Department, ... I trust that...the one to which I have the honour to belong may be acknowledged in a similar way.

"The Artillery regiment to which I am proud to belong... can never...compete with the Line in point of promotion, and although of 17 years service in India, added to 2 years spent at Addiscombe after attaining the age of 16 years, I find myself superseded...by officers very many years junior"[3].

Govt. refused to sanction such promotion "considering such rank to be quite uncalled for", and again in 1853 they saw "no sufficient grounds for raising his salary"[4].

Thuillier put the matter forward yet again in 1855, and this time it was forwarded to the Directors who sanctioned the grant of "the official rank of Major" so long as Thuillier was empd. as Supt. Rev. Svys. and DSG[5].

The biggest change that Thuillier carried out at SGO. was the installation of the Lithographic Press by transfer of a few hand presses with staff from the local Govt. press early in 1852 [327–8]. The new office had hardly started when he was called on to undertake the printing of postage stamps pending supply from England. The work was entirely new to everyone in Calcutta, but by a triumph of organization and improvisation Thuillier printed in the first 8 months the enormous quantity of 40 million stamps—three values—blue and red—designed by his Survey staff. He was granted a special allce. of Rs. 300 pm., for the period 15–2–54 to 3–11–55 [9, 329, 332–5].

A map depot was gradually organized with regular sales dept. [322–7]. Progress was also made in technique of lithography including printing in colours [pls. 2, 10, 11, 15]. During emergency of 1857 large numbers of special maps were turned out for use of troops passing through Calcutta to take part in mil. operations [189, 323–4, 330–1, 349, 354–5, 483].

From time to time Thuillier took control of GTS. and topo. parties that lay beyond SG.'s reach, as during the 1857 period [176–7, 427], and his responsibilities grew ever heavier.

After the loss of Renny and Logan, he remained the one officer in whom Waugh had complete confidence, and could appeal to him as an old friend. Waugh envied his easy temperament [10, 91, 94–5, 320, 346, 349 352, 395, 400].

Though living this sedentary life in his Calcutta office, Thuillier was a vigorous administrator and ruled his rev. svys. with firmness and discretion. He had strong views on their organization, and expressed them even "with asperity" [350–1]. He protested against excessive control by the Punjab admin. over svy. parties working over 1,000 miles from his office [349–50]. He waxed extremely angry indeed when the Ch. Compr. failed to co-operate over the electric signals to the Fort semaphore [139–41, 355, 522].

After corr. on the subject of maps, he received a brief note from the QMG.; "Very Well. I will think over about what you have said about the map. Very busy just now". On this Thuillier scribbled a pencil note; "I shall be busy too when they want anything again. FILE". HLT. 16–9–61.

In all these years 1847 to 1861 he left Calcutta but once when in Oct. 1859, he took two mo. leave to visit Waugh at Mussoorie on deptl. business.

Since Sept. 1850, he had been an active member of the Calcutta Municipality, and when he resd. in 1862 he received the warm thanks of Govt. for these services. He was for many years a valued member of the Council of the ASB.

When the time came for Waugh to suggest a name for his successor, he stressed the great advantage of having one officer holding the two offices of SG. and STS., which would not be possible if Thuillier became SG. as he so richly deserved. He hoped that any break in this association would be only temporary. Govt. nominated Thuillier as SG. and Walker STS.; Thuillier being given charge of both the Rev. and Topo. branches, for which he was particularly qualified [340, 425, 428].

He took over at Calcutta on afternoon of 12–3–61, and held office till he ret. 31–12–77, during which period the GTS. was ably directed by James Walker. Great progress was made on the rev. side, and the system of cadastral svy. introduced, whilst topo. svys. and the reproduction of maps expanded enormously [196–9, 345, 376, 388, 425].

As SG. Thuillier maintained hdqrs. at Calcutta, making frequent tours of inspection [488, 509]. He took furl. 1865–6; was on duty in England for 8 mo. during 1868 arranging tr. of pubn. of the Atlas sheets to India [311] and took 3 mo. leave to during England 1874 [341].

In 1862 Col. Vincent Eyre, IG. Ordn. Ft. Wm. acknowledge a map of Calcutta area, "My beloved Thuillier, Your...map has just come. Let me embrace you for it. Really you deserve well of your country, and I'll report the Queen to knight you. But, Oh, my friend, there's one great omission in the map, AWFUL to think of. Barrackpore is there in large letters, as big as Calcutta. But, where—Oh Where, Sir—is ISHAPORE? It is absolutely nowhere. I could scarcely believe my senses.

"Perhaps, since I am no longer there, you may have thought it was no longer important, but the very fact that it was so long my residence makes it "a thing of beauty for ever" as Madam Rachel would say.

"I'm therefore disappointed in you, Thuillier, and in fine thereof, I won't ask the Queen to make you a Knight, at least not until this awful omission is rectified[6]".

THUILLIER, Henry Ravenshaw. Ben. Engrs.
b. 26–3–38. d. 4–3–1922.
2/Lt. 12–6–57 ... Lt.-Col. RE., 12–8–86; Col. 7–10–87; ret. 26–3–95.
SG. 19–2–87, till ret. after extensions, aged 57.

[1] DDn. 462 (321–2), to Mil. Dept. 13–6–49. [2] Tickell, Capt., 25–12–47 [254, 538]. [3] DDn. 474 (179), to SG., 30–8–49. [4] SG. to Mil. Dept., 462 (342–3), 8–9–49, 541 (76), reply, 22–9–49, 589 (115), 16–11–53. [5] GD. to B., Mil. 7–5–56, (19) GO. GG., 25–6–56; DDn. 648 (291). [6] DDn. 30 (931), 30–7–62, from Eyre (1811–81), Ben. Art.

eld. son of Gen. Sir Henry Landor Thuillier (1813–1906) [536], by his 1st. wife; father of Leslie Cardew (b. 1877), ISO., S. of I. 1901–32.

ed. Wimbledon; Addiscombe 1855–7, 1st. prize mil. surv.g.; Chatham, 1857–9.

m., Mussoorie, 4–6–67, Emmeline Theodosia, dau. of Fleetwood Williams (1811–94), BCS.; CSI.

CIE. 1893; KCIE. 1895.

Ubique; *DIB.*; Conolly (93/330); *SI Lists*, 1–7–81; 1–7–84; *GR. 1894–5* (frpce), portrait in oils by G. G. Palmer, 1887 [536 n.1]; *SI. Notes*, 1–12–87;

arrd. India, 29–4–59; 2nd. Asst. GTS., 21–5–59; 1st. Asst., 1–2–61; Survr. 3rd. gr. 1–4–66; 2nd. gr. 1–10–67; Dep. Supt. 2nd. gr. 1–4–74; 1st. gr. 27–10–78; furl. 2 y. from 17–11–79 [380–1, 399].

12–9–59, from duty at SGO. Calcutta, to Gt. Indus ser., joining in fd. 20th Nov. to work under Basevi [49, 490]; June 1861, joined Kashmir svy., and directed to extend trgn. into Kāgān, fixing peaks of Hindu Kush, with topo. sketch; "The following places are but very vaguely known, ... Swat—Panjkor—Dheer—Chitral—Yasseen [227]"[1].

Montgomerie reports to SG. a few weeks later; "I heard from Master Harry a day or two ago. He had got down safe into Khagan, and the weather had at last allowed him to move ahead. He has been very unlucky as to the season; however, I think he will be all right if the fine weather holds out a few days longer"[2].

1862, tr. to Levelling Party, and then in 1863 to ch. E. Calcutta Longl. ser., followed by Brahmaputra ser. 1867; Kumaun & Garhwāl topo. 1870; Dehra Dūn & Jhaunsar Bhāwar, 1873; Mysore topo. 1877; furl. 1871–2, and 1879–81; offg. STS. April to Oct. 1876; DSG. Rev. 1874; offg. SG., 24–2–86; confirmed, 19–2–87.

Miss Tanner records that Harry Thuillier "came to stay with us at Bath; a crusty man with a perfectly charming wife"[3].

TICKELL, Samuel Richard [IV, 471–2]. Ben. Inf.

b., Cuttack, 19–8–11. d. 20–4–75.

Ens. 12–6–29 ... Capt. 25–2–47 ... ret. as Hon. Col. 24–1–65.

Son of Samuel Tickell (1785–1817), Ben. Inf., Hodson, IV (276), and Mary his wife.

ed. Addiscombe, 1827–9.

m., Bankura, 11–7–44, Maria Geogiana, dau. of J. W. Templer, Hodson, IV (276–7).

1832–6, route svys. and sketches in Chota Nāgpur [IV, 269], contributing notes on country and peoples to ASB.

20–3–46, asst. to Comnr., Akyab, Arakan.

GO. GG. 9–2–48, appd. to act in ch. rev. svy. Bhāgalpur *vice* Sherwill on furl. [433]; senr. to DSG. in mil. rank [537 n.2]. Arrd. Bhāgalpur 2–3–48 and handed over to O'Donel 27–9–49, to resume post in Arakan [399, 400] *IO Cat.* (172), geol. map, Bhāgalpur.

Having no previous experience of rev. svy., left all profl. work to assts., confining himself to admin. duties. This resulted in such errors and false work that all work of season 1848–9, had to be re-survd. later [4–5, 241, 255 304–5].

30–12–52, appd. DC. Amherst & Tenasserim.

TREVOR, William Spottiswoode. Ben. Engrs.

b. 9–10–31. d. 2–11–1907.

2/Lt. 11–12–49 ... Lt.-Col. RE., 19–8–74 ... ret. as M. Gen. 20–2–87.

Son of Capt. Robt. Salusbury Trevor (1802–41), Ben. Cav., kd. at Kābul Dec. 1841; Hodson, IV (305–6), and Mary his wife, dau. of Wm. Spottiswood of Glenfernate, co. Perth.

Addiscombe.

m., Calcutta, 19–6–58, Eliza Anne, dau. of Rev. H. Fisher, Ben. Eccl.

VC., Dewāngiri, Bhutān, 1865; CSI.

Ubique; Conolly (9/272); *Who Was Who.*

Burma War, 1852–3; wounded at capture of Rangoon, 12–4–52; again at Donabyu 19–3–53.

Dec. 1853, with Williams on svy. Rangoon to Pegu: 22–1–54, appd. to Pegu Svy.; to Calcutta to obtain diff. of long. between Calcutta and Rangoon by chronometer; 1–12–54, svy. of town, cant., and environs of Rangoon [195–6, 384, 400].

FD. Sel. XV. report on svy. 31–8–55.

From Sept. 1856 to engr. duties; 1865, Bhutān War; capture of Dewāngiri Ft., wounded, and awarded VC and Bt. Maj.

Later OF. PWD.; DC. Rlwys.; Sec. to Govt. of I.

TURNBULL, Frederick Henry. Ben. Art.

b., Calcutta, 8–9–29.

kd. by mutineers, Jhānsi, 8–6–57 [395, 483, n.1].

2/Lt. 8–12–48; Lieut. 1–7–53.

Son of Montague Henry Turnbull, BCS., and Eliza Ann Colvin his wife.

GO. GG. 11–10–55, appd. Asst. Rev. Survr., joining party in Bundelkhand, under Burgess, 28–12–55 [267, 400].

VANRENEN, Adrian Deneys. Ben. Inf. & SC.

b. *c.*, 1–3–31. d. 3–7–94.

Ens. 7–7–49 ... Capt. 7–7–61 ... ret. as Col. 14–7–77.

g. son of Brig. Jacob Vanrenen (1762–1828); Ben. Inf. [II, 402, n.3]; eld. son of John Heyning Vanrenen (1804–67), Ben. Inf., Hodson, IV (343–4), and his wife Yda Johanna, only dau. of Adrian Christian Deneys, of Roode Bloem, Cape Town; she d. 25–10–96.

Adrian's only sis., Ada Maria, b. April 1851, m., 17–6–73, Thos. Hungerford Holdich (1843–1929), S. of I., RE.

ed. as Survr. and licensed as such at Cape.

m., Landour, 22–10–60, Louisa Elizabeth, dau. of late Rev. Chas. Piffard; she d. 10–4–1914, at Camberley, Surrey; dau. Yda Nina Florence, d., England, 11–6–1960, aged 86.

Ubique; *Notable Record.*

July 1855, with Bengal PWD.

8–7–56, appd. Asst. Rev. Survr., Bharatpur, recess qrs. at Dehra Dūn, 1857, [6, 267]; 1858, succd. to ch.; and tr. with party to Jhānsi to resume work of Burgess' party [267], extending to Lalitpur 1860–1 [10, 268, 364, 451].

14–9–62, from Landour asks SG. for map of "Saugor & Nerbudda Territories" to be sent by Grindlay's to the Cape, "to enable my father to see our field of employment"[4] 13–11–63, leave to Europe on mc. 1866–73, rev. svy. Morādābād; 13–1–73, on furl. for 2 y. [396–7, 400].

VANRENEN, Donald Campbell. Ben. Art. & SC.

b. 1–6–22. d. 1904.

2/Lt. 10–12–39 ... Lt.-Col. BSC., 18–1–61 ... M. Gen. 1–10–77; ret. as Lt.-Gen. 31–12–78.

Son of Capt. Tunus Augustus Vanrenen (1793–1836), Ben. Art., eld. son of Brig.-Gen. Jacob Vanrenen [*sup*], and his wife Harriot Catherine, dau. of Adm. Donald Campbell, RN.; 1st. cous. of Adrian [*sup*].

m., Bengal, 12–9–49, Julia, dau. of Dr. Sullivan, Ben. Med.; she d. 20–12–1916.

Ubique; *Notable Record.*

17–10–43, appd. Asst. Survr., Canals, Sind, under Baker [IV, 417; V, 276]; BMC. 13–9–44, to tempy. ch. of Art. dett. at Sukkur[5]; Nov. 1844, 3 mo. leave to sea on mc.

[1] DDn. 52 (68–9), from TGM., 3–6–61. [2] DDn. 25 (168–9), 21–9–61. [3] letter to RHT., 1961. [4] DDn. 30 (1207).
[5] DDn. 415 (4), MAG. to GG. in C., 26–1–44; cf. Wm. Brown [IV 424], against hill tribes on N. Sind border.

3–10–46, appd. Asst. Rev. Survr. cis-Sutlej Svy. under Stephen [269]; 8–7–47, to ch. Ajmer Rev. svy. [265–6, 364]. Sept. 1848, moved party to N. Rohilkhand, recessing Naini Tāl, where he influenced appt. of his bro-in-law Julius Dennys to rev. svy. of Nimach [6, 67, 259–6, 266, 324, 365, 433, 505].

1854, moved party to Jubbulpore, and again during 1857 to neighbourhood of Nāgpur [179, 268, 486]; 2–3–59, furl. on mc. 15 mo. On return, 28–5–60, to Lucknow to raise new party, 2nd. Div., for Oudh rev. svy., commencing work in Unao 1–10–60 [264].

Nov. 1865, Bdy. Comnr. LP.; 23–2–66, Supt. Rev. Svy. LP.; 9–7–67, furl. on mc. 30–11–70 and again 31–11–72, Supt. Upper Circle, tempy.; 1876, Supt. all Bengal rev. svy.; as DSG. & Supt. Rev. Svy. Bengal; 31–12–78, resd. and ret. to Europe [10, 396–7, 400].

WALKER, James Thomas. Bo. Engrs.

b., Cannanore, 1–12–26. d. 16–2–96.

2/Lt. 9–12–44 ... Lt.-Col. RE., 27–2–64 ... ret. as Gen. 12–1–84.

STS. 13–3–61; SG. & STS., 1878–84[1] [399].

Eld. son of John Walker, MCS., and his 1st wife, Margaret Somerville, dau. of w. Allan, of Leith.

Addiscombe, Feb. 1843 to 1845; Chatham, 1845–6.

m., Ambāla, 27–4–54, Alicia, dau. of Gen. Sir John Scott, KGB. (1797–1873) and his wife Alice; *DIB.*; she d. 5–8–1911, aged 80; their only son, Maj. H. J. Walker RE., d. on active service in France, 25–8–1916.

FRS. 1865; FRAS. 1863; FRGS. 1859, and member of Council ten years from 1885; CB. 1877; Hon. LLD., Camb., 1883;

Portraits; group of 1861 [517, pl. 21]; in oils by G. G. Palmer [536 n.1], frpce. *GTS.*, XVII; photo. of 1883 [pl. 22].

DNB.; *DIB.*; *SI Lists*, 1881; 1884; Markham (123, 480); *Punjab Sel.*, II (xii), 1855; Conolly (107/125); *Addiscombe*; obit. *GJ.*, VII (320–3); repr. *SI Notes*, March 1896; *RS. Progs.* LIX, 1895–6 (xliii–vi); Sandes, II (24–2).

arrd. Bombay, 10–5–46; Asst. to CE. 4 mo.; 6 mo. leave to Madras from 16–9–46; Ex. Engr. Upper Sind, May 1847 to Oct. 1848; 2nd Sikh War, 1848–9; fd. engr. at siege of Multān, holding ch. of party of S & M. at assault of Mohon gate 2–1–49; battle of Gujrāt, 21–2–49.

March 1849, given ch. of mil. svy. of Peshāwar and 10 m. radius; commenced in April under orders of Bd. of Admin., Lahore. After first 3 mo. had no asstce. except 2 untrained Indian survrs. but extended svy. to cover Yusufzai to N.; Kohāt and Bannu to S.; sketched into tribal hills as far as possible with escort of a couple of sowars. No high standard of accuracy aimed at, but every effort made to cover widest area in shortest time. Engaged in expns. against Afridis 1850, and Utmān Khel 1852 [4, 209–10, 214–7, 380, 387, 447–8, 474–5].

From 1851 came under control of SG., under whose advice higher accuracy was obtained [286, 337, 363, 448]. Fd. work completed by April 1853—nearly 9,000 sq. m. svy., and another 11,000 sketched beyond tribal borders. Completed map in Mussoorie during 1853, receiving instn. in GTS. obsns., from Renny-Tailyour [138, 317, 523].

Left Dehra Oct. 1853, with part of Jogi-Tila est., and "left Lahore early on the morning of the 12th Nov....to join the Chief Commissioner at Peshāwar ...[for] military service". Reported to SG. at Chach base-line 1–12–53, from which date was appd. 2nd. Asst. GTS., being promoted 1st. Asst. 24–3–54 [43].

From Chach assumed ch. of Jogi-Tila ser. in the fd. during March 1854, working S. from Jhelum. Continued during season 1855–6, shewing great enterprise in overcoming various technical difficulties, including those of refraction by means of spirit-levelling [52–65, 75, 111, 132, 154].

Oct. 1856, tr. with party to work on Gt. Indus ser., making hdqrs. at Murree [46–9, 361, 370, 446, 482].

May 1857, volunteered for mil. service, and joined Chamberlain's Punjab column[2]. "I am now at Wuzeerabad with the troops who are marching down country. Sir John Lawrence...said that he would gladly accept my services, and requested me to join Brigr. Chamberlain forthwith. I did so at Rawalpindi just in time to accompany him by dak to this place. ... I purpose to remain with him until Delhi is again in our hands. ... I feel sure you will be of my opinion that no British soldier should think of sheathing his sword until Delhi is once more in our possession"[3].

With the forces before Delhi he was wounded in action 14–7–57, and then went down with cholera. Baird Smith, CE., writes of him as "a young soldier of rare daring and self-possession, who was shot through the thigh after performing one of those cool and noble acts of devoted valour. ...

"Directed to blow in the gate of a serai occupied...by the enemy, he could only obtain a number of cartridges from the nearest field battery. ... Carrying these...himself in full view of the enemy under a heavy fire, he was fortunate... in lodging them against the gate without being hit. He lit the match and retired but, seeing...that the portfire had burned out he advanced again and relit it, when again it failed. He then procured a musket, moved out to the vicinity of the gate, and fired into the powder, exploding it at once and blowing away the woodwork effectually.

"The attacking party at once rushed in. ... After this successful shot, however, Lieut. Walker received a very severe gunshot wound in the thigh. ... Before recovering... an attack of cholera intervened, and his services were lost for the remainder of the siege". For his services Walker received a brevet majority and medal with clasp, and gratuity of a year's pay for his wound[4].

13–9–57, granted 3 mo. leave to Murree on mc., resuming his svy. interests at once. SG. was anxious to start levelling ops. to bring up reliable heights to the Punjab from sea-level at Karāchi [74–5], and being assured that Sind was in a state of "profound tranquility", asked Walker whether his health would permit him "after reconnoitring the ground...to initiate the levelling operations. ...

"The trip might do you good, as you would get sea air and sea bathing at Manora and, provided you do not yourself remain out too long in the field or work too hard, or expose yourself too much, the voyage down and up might prove beneficial ... You would need to take an assistant to leave in charge of the levelling"[5]. ...

Walker pointed out that it was too late in the season to organize anything effective; that it would be impossible to recruit the necessary fd. est., especially as service in Sind was always unpopular with Punjabis [391], and lastly that there was no hope of obtaining the necessary levelling insts. and equipment. He suggessted that steps should be taken to start serious ops. in season 1858–9 [76, 133].

[1] on Walker's leave pending rett., post STS. became DSG. Trig. [50–2]. [2] Sir Neville Bowles Chamberlain (1820–1902) [217]. [3] DDn. 710 (174), to SG., 28–5–57. [4] *Addiscombe* (536–6). [5] DDn. 711 (37), 21–11–57.

He was now put in general ch. of the Indus ser. which for this season was confined to the apprx. opns. of selecting stations and erecting towers, with Basevi and Armstrong working from the N. and S. respectively [48–9]. He writes on 28th Oct. that "my health is so much improved that there is every probability of my being able to take the field by the middle of December, when my leave of absence on medical certificate will terminate"[1].

He reported later that "on the expiration of my leave... I took the field, marching to Kalabagh, when I went down the river by boat to Dera Ghazi Khan. Below Leia I met Lieutenant Basevi. I only remained with him two days, and then proceeded to Sind to superintend Mr. Armstrong's operations. I marched from Dera Ghazi Khan to Jacobābād, visiting the low hills to the north-west of Kusmore"[2].

He spent the rest of the season reconnoitring the line for levelling through northern Sind [3, 77].

For season 1858–9 the trgn. was divided between 3 assts. whilst Walker himself with Branfill and a new party started the levelling through Sind [48, 492]. For the next two years he devoted nearly all his time to the precise levelling that was to play such an important part in the opns. of the GTS. Working in close consultation with Waugh he devised and procured the insts. and all apparatus—thought out the best system of fd. work—and put it to practical test on the ground. In Nov. 1860 he submitted account of work completed, and discussion of methods followed, which held good for the next 50 years with but few modifications [5, 79–80, 159–60, 338, 382].

During April and May 1860 Walker with Basevi and Branfill of the GTS. and Johnstone from the Derajāt svy. accd. mil. expn. into Mahsūd country, then entirely unknown [49, 217]. Walker had just returned after carrying his levelling down to Karāchi.

"I had arrived at Lahore on my way back to Rawalpindi when I first heard of the...expedition from the Lieutenant Governor, who said that I might have an opportunity of... laying down the hills between our frontier and Ghazni for which I last year solicited, but was refused permission to attempt to ascend the Takht-i-Sooliman.

"The expedition offered so many prospects of an extensive addition to the hill triangulation of the Great Indus Series that there could not be a doubt as to the propriety of joining it. ... Knowing that Captain Johnstone...was also to join, I had anticipated that he and his assistants would undertake the topographical portion, ...while we would devote our energies to the trigonometrical. ... Captain Johnstone, however, arrived with no instrument but a compass, and no assistants [508]. ...

"Fortunately Lieut. Basevi had brought a perambulator,.. and he undertook the traverse. ... He was assisted by... Branfill, who sometimes recorded, sometimes observed, for him, and at other times carried on the traverse while Lieut. Basevi ascended an adjacent hill to sketch in the surrounding country. I consider them to have been the hardest worked men in the expedition [430, 492]. ...

"We brought...the 12-inch theodolite; ... unfortunately we never had occasion to use it. The expedition passed within 4, 7, and 5 miles respectively of Koondi Shar, Peerghur, and Shewy Ghur all most enviable mountains for a surveyor to get on the top of. But neither mountain could have been ascended without a great risk of life, probably not without fighting our way up to the summit"[3].

Took over as STS. on Waugh's rett., 13–3–61[4] [525] and administered GTS. as a master geodesist for next 16 years, less disturbed by mundane affairs than Everest and Waugh. He continued to guide the GTS during following 7 y. as SG. and STS., making total period of 22 years incl. periods of furlough [10, 32, 340–1, 356, 380–1, 389, 490, 498, 502, 506, 522, 537].

His most important task was the final reduction of prcpl. trgn. and the dispersal of errors generated in the several chains of triangles, which he arranged into five major figures—the four great quadrilaterals and the southern trigon [107, 125, 129].

The results were pub. under title "*Account of the Operations of the Great Trigonometrical Survey of India*, the first 9 vols. being ed. by himself, with special attention to historical notes.

Under his direction the prcpl. trgn. was completed in the fd. over the whole peninsula—precise levelling was extended —and regular tidal, lat., and pendulum obsns. put in hand. He took keen interest in the geogl. mapping of Central Asia and had cordial corr. with Russian and other cartographers. He warmly supported the work of Indian trans-Himālayan explorers [311, 448–9][5].

During his visits to Europe he made contact with a wide circle of geographers and geodesists, and his collns. of letters received from these distinguished scientists covers an immense variety of subjects [151–2][6].

Airy, the Astronomer Royal, and Sabine, on distribution of errors and pendulums—Stokes, on gravity and pendulums—Andrew Clarke, of OS., on computation of triangles, standards of measure, telegraphic longitudes—Stewart of Kew Obsy., on pendulums and magnetism—Clements Markham, Geogl. Dept., IO., on Indian Atlas sheets and Central Asian geogy.—Henry Yule, Central Asian Geogy.—Francis Galton, on *Hints to Travellers*—Wm. Thomson [Lord Kelvin], Tides—Otto Struve, Imp. Obsy., St. Petersburg, Central Asian geogy.—Petermann of Gotha, Germany, Central Asia—Pogson, Astr., Madras, obsn. of eclipses—von Strubenzoff, Russian maps, Central Asia—Edward Roberts, tides—Isaac Todhunter, figure of the earth—and many others, 224 letters in all [533].

Leave to Europe 1863–4, travelling via Russia, and again 1870–2 [503]; Sept. 1871, asstd. from London in obsg. diff. of long. with Teherān [Markham, 188]; made final arrangements for pubn. Indian Atlas sheets in England during final illness of John Walker [III, 510]; "Latterly his medical attendants have not permitted him to be spoken to on the subject. ... I proposed...an arrangement...with Mr. John Walker's younger brother, Charles, who had been in partnership with him, but has long retired, ... but Mr. Charles died very suddenly. ... I was then on the point of returning to India but...was detained in England for a few months...to make arrangements for the completion in this country [India], not only of the copper plates which were in the hands of the engravers, but of several new plates [516].

"No one who could give me any information...excepting Mr. Walker who was too ill to be spoken to. Eventually I came across a ms. memo book in Mr. Walker's office in Castle St., Holborn, containing tables and other data on which the projections must have been based" [III, 286; V, 311][7].

On furl. again 1876–7, and finally, "pending retirement" from 12–2–83. Acted as SG. and Supt. Topo. Svys. during Thuillier's absence, 1865–6, 1868–9 and 1874, before taking over ch. 1–1–77 [322, 516, 525].

1885–95, took active interest in work of Council of RGS. and at various times wrote prof. papers for pubn. incl. *Ency. Brit.* 7th edn. *Traverse Svys.*—*Cal. Rev.* XXXVIII, 1863]

[1] DDn. 710 (183), 28–10–57. [2] DDn. 692 (489), JTW. to SG., June 1858. [3] Pirghar, 11,532 ft.; Shnidhar, 10,957 ft.; DDn. 710 (308), JTW. to SG., 5–6–60; DDn. 666 (181), SG. to DSG., 30–8–60. [4] Astr. Asst. 1860–1, vice Strange [380–1]. [5] Maps of Central Asia; GBO. Lib. E., 5–6. [6] Eur. letters dated 1865–76; originals, GBO. Lib. Q 67/8; extracts in RS. & Camb. Univ. libraries. [7] Markham's *Abstract* (74–5); *GR. Trig. 1872*; Markham (414, 431–90), memo by JTW.

JASB XXI, 1862, on GTS.—*RGS. Progs.* VII, 1885 (674–92), reprn. of *Paper of Indian Surveys—Progs. B. Assn. Geogl. Sec.* Aberdeen 10–9–85; JTW. Presdt.—*The Indian Engr.*, 22–1–87 (171–5). *Phil. Trans.*, RS., 1895, *India's Contribution to Geodesy* [89].

WALKER, Reginald John. Ben. Engrs.
b. 6–8–22. d., unm., 24–4–47, at Bamanjora, en route to Darjeeling.

2/Lt. 11–12–40 ... Lieut. 5–9–44.

Son of John Walker of Purbrook Park and Maria Theresa Henrietta his wife.

Addiscombe and Chatham.

Conolly (89/210).

16–12–43, applied from Ferozepore for appt. to GTS., having "a great desire to belong to that Department, ... which is confessedly the most scientific, and therefore most interesting".

GO. GG. 13–9–44, appd., when Renny left on furl., 2nd. Asst. GTS. and posted to Chendwar ser. for training under Logan. Joined during Oct. from comd. of No. 6 co. S & M. at Ferozepore [13, 382, 399].

DO. 2–8–45, posted to ch. Maluncha ser.; "On account of the reputed insalubrity of the country in the vicinity of Bhaugulpore, Lieutenant Walker is directed to take every precaution to ensure the health of the establishment"[1] [14, 368, 412–3, 456–7].

Extended trgn. N. to *tarai* belt where Kosi breaks from the foothills, and then swung E. to carry NE. Longl. ser. through N. Purnea, having spent recess 1846 in Darjeeling. Clouds prevented obsn. to snow peaks at the time of obsg. final angles [14, 17, 81–3, 104, 120, 149–50, 163, 361, 453].

Opns. of 1846–7 lay through unhealthy *tarai*, and by Jan. 1847, he had carried recce. E. and selected site for meast. of Sonakhoda base-line which SG. approved later that month [17, 19, 186, 336]. Then returned to start final obsns.; completed 19 triangles of this section when fever compelled him to break off. Died before reaching Darjeeling [2, 20, 83, 379, 461].

His death was a serious loss to the Department, for he was, writes SG., "one of those rare characters peculiarly fitted by energy of disposition and mathematical acquirements to contend with the difficulties of the G.T. Survey[2]".

WAUGH, Andrew Scott [IV, 472–4]. Ben. Engrs.
b., Cannanore, 3–2–10. d. 21–2–78[3].

2/Lt. 13–12–27 ... local Lt.-Col. 3–12–47;
Lt.-Col. RE. 20–9–57; M. Gen. 6–8–61.

SG. & STS. 16–12–43 to 12–3–61.

Son of M Gen. Gilbert Waugh, MAG., Madras, and Charlotte his wife, dau. of M. Gen. Geo. Wahab, Mad. Est.

ed. Edinburgh High Sch.; Addiscombe, 1827–8.

m., 1st., Calcutta, 8–6–44, Josephine Morison, dau. of Dr. Wm. Graham of Edinburgh; she d., London, 1866; their son, Gilbert Wm. Renny Maxwell, b. Mussoorie, 10–12–47, was comnd. Ens. 78th Hldrs., 1869.

m., 2nd., in England, 1870, Cecilia Elia Adelaide, dau. of Sir Thos. Whitehead, KCB., Ben. Eur. Eslrs., of Ecclestone, Lancs.

Kt. Bach. 10–12–60; Athenæum Club; FRS. 1858; FRGS. Gold Medal, 1857; Council, 1867; VP. 1868; DL. City of London.

Portraits—in oils by John Peyton, received in SOO., 1886—in photo. group of March 1861 [517; pl. 21].

DNB.; *DIB.*; Conolly (88/154); *JRGS.* XXVII, 1857 (XC); Hodson, IV (412–3); *RAS.* (*mn*), XXXIX (216); *Addiscombe* (423); Markham (424–7); Thackeray (158) & obit.; *RGS. Progs.* XXII, 1877–8 (315–7); *Geo. Mag.*, V, 187; (68); *REJ.*, 1878; *Nature*, XVIII, May–Oct., 1878 (45); *Friend of India*, 7–2–61.

arrd. India, 25–5–29, July, to S & M., Aligarh; Oct. 1829, to FWD. 11–6–30; offg. Ex. Engr., Allahābād 30–10–30; leave to FWI., 6 mo.; Feb. 1831, Asst. Supt. Ft. Wm. Foundry; GO. GG., 13–4–31, Adjt. Engrs.

GO. GG. 2–7–32, appd. 2nd. Asst. GTS.; BMO. 30–10–34, 1st. Asst.; 27–4–35, Astr. Asst., GTS. [IV, 356; V, 523].

1833–5, in ch. Ranghir ser., and then with Everest on Gt. Arc; 1841, meas'd. Bīdar base and after completing trgn. to south returned to Dehra April 1842; 1942–3, ran trgn. conng. N. ends of Ranghir and Amua ser.; Oct. 1843, with Everest to Calcutta, to assume duty as SG. and STS., 16–12–43 [IV, 473].

Oct 1844, four mo. after marriage and severe attack of fever, moved hdqrs. to Allahābād [341]; Sept. 1845, obsd. at conng. station of Karara ser. nr. Rae Bareli [III, pl. 3; V, 11, 156; pl. 28], continuing tour via Lucknow to Agra, returning via Mirzāpur; Dec. 1846, inspected site for Sonakhoda base below Darjeeling, and spent 1847 obsg. snow peaks of Sikkim and conducting meast. Sonakhoda base [20, 83]; marched to Dehra Dūn to take up residence in Mussoorie from May 1848 [337].

During cold weather 1849–50, visited Peshāwar to select site for base-line nr. Attock, making second visit 1851–2, to meet Robinson and Walker [215, 287, 337].

1850–1, visited Armstrong in Bihār, and 1852–3 inspected start of Assam trgn. under Du Vernet, whose tr. to this ser. gave rise to much ill-feeling between them, ending with Du Vernet's resgn. [393–5]. March 1853, visited Thuillier and the hdqr. offices [337–8].

Devoted cold weather of 1853–4, to meast. Chach base [42–3], and 1854–5 to Karāchi for similar purpose. Making journey by river from Ferozepore, was laid up by fever for several weeks at Mithankot [44, 338, 532]. From Karāchi by sea to Calcutta.

No record of further touring after 1855, being fully occupied with administrative work which had grown to a vast extent [338–40]. Deeply engaged in prof. work, of both trig. and topo. interest, incl. problems of refraction and heights of the snow peaks [63–6. 90–6] and inauguration of spirit-levelling [74–80]. He had earlier been led to study of the mysteries of Himālayan attraction by persistence of Robt. Shortrede, and had been fortunate in arousing interest of Archdeacon Pratt [133–7, 520–1].

Kept close hold on work of the topo. parties, demanding high standard of accuracy in detailed svy. and map drawing, with faithful depiction of ground and clear legibility [281–91].

It was well for the Dept. that he had inherited the dual role of SG. and STS. He had the width of view and soundness of judgement to control and

[1] DDn. 455 (42–3). [2] DDn. 462 (148–50), to Mil. Dept., 1–8–47. [3] not 1877 as given by Conolly.

guide all branches of the Dept., and showed particular wisdom and firmness in handling his meagre staff of prof. officers [281, 313].

At the time of Everest's departure the only other possible officer for the post of STS. was Renny, who was not anxious for continued service in India, and it was not till 8 years later that a number of talented young officers fit for ch. of the geodetic side had been brought in.

It may not be unfair to put on record a critical note made by Tennant who was one of these young officers with progressive ideas. "Waugh...did a good service in getting over the *hatred* of the Department which arose in Everest's times and making it tolerated. But it is useless to shirk saying... that for many years he was a bar to progress with which he had no sympathies, whilst his *democratic* theories led him to practical mischief. But I am sure that Waugh was kindness itself; it was no mere policy, but the natural kindness of his disposition that often led him wrong, and "I am quite sure that half his *humbug*, as people call it, was felt" [534].

It is possible that Everest's ruthless discarding of officers who fell short of his standards had deterred some young officers from offering their services, but the great shortage of educated officers during Waugh's early years had been due to the Afgbān, Sikh, and Burma wars.

Waugh may not have been ready to accept all the ideas of young officers 20 years his junior, but he was far from narrow-minded. He was impatient of dilatory work, and eager for progress, but was exceedingly cautious in accepting new ideas, as in the problems of refraction and the promulgation of heights of the snow peaks. He held firmly to established principles as shewn by his many prof. notes and instructions [9–10, 97–8, 102, 282–3, *et passim*].

His "democratic theories" were possibly ahead of his time, but his ready recognition of the merit of junior officers and their fitness for responsibility was all to the good of the service [408–9].

His lapses into pious sentiments when dealing with the troubles and shortcomings of his staff, and his occasional fulsome praise might be interpreted as "humbug", but were typical of the age. On the other hand he could express indignation in no uncertain terms when occasion demanded, and it is difficult to withhold sympathy for his victims in such cases as Keelan's hesitation to run topo. svy. up the Sutlej valley in midwinter [201, 422–3]—the transfer of 50-y. old Du Vernet to Assam [393–5, 496–7]—or of 54-y. old Shortrede to Sind [391, 530–1].

There was no doubt whatever of the genuine warmth of affection and regard that were voiced at the farewell functions before his departure from Calcutta, 16–3–61 [340].

Amongst many tokens of appreciation [339–40] were the RGS. gold medal which reached him in 1857 through Geo. Everest and CD. [338–9][1] and the gift of 2 vols. of Wellington's *Dispatches* from the 2nd Duke[2].

He took over the Dept. at the end of 1843 with 12 executive officers, and left it with 24 early in 1861[4]. He was particularly proud of his record of 32 y. service in India with but one spell of 6 mo. leave at end of 1830 [395, 399].

He d. at his home, 7 Petersham Terrace Kensington. "For the last five years...his health had been failing. He was missed at his seat at the Council table of the Geographical Society, and still more was the absence of his genial smile and kindly greeting regretted by the Geographical Club. But his friends had the pleasure of seeing him at the Athenæum almost to the last"[5] [502].

WEBB, George Parker. Registrar.
b., in India, July 1816.

Hd. Wr., SG.'s fd. office, July 1834 ; Regtr., 1–11–41; furl. to Europe on mc., rejoining Nov. 1856; ret. after 1866.

nat. son, East-Indian, of Maj. Nathaniel Spencer Webb (1787–1833), Ben. Art., Hodson, IV (46–7); possibly kin to Wm. Spencer Webb (1784–1865) [III, 512–3].

With SG. on many tours—Oct. 1843, Dehra Dūn to Calcutta—Oct. 1844, Calcutta to Allahābād—1845–6, from Allbd. to Lucknow, Agra, and return—1846–8, Allbd. to Darjeeling and then to Dinapore to conduct SOO. to Dehra Dūn (341–2, 359, 372, 521]; 1853–4, Dehra Dūn to Chach base and return.

In recdg. increase of pay, SG. writes, 8–6–58 ; "Mr. Webb has few equals as a man of business and of cultivated literary tastes. He entered this Department after the unexpected death of his father, the late Major Nathaniel Webb of the Artillery, who had made it his care to give his son a superior education. ... He...speedily rose to the top of that branch to which he was posted. ... The situation of Registrar and Accountant, one of the most important of all, has remained on its ancient inadequate scale of salary [II, 309, 352].

"Considering the great importance of his office, the difficulties of its duties, ... the inadequacy of the existing salary, ... I...recommend that his salary and allowances [Rs. 466–10–8] should be raised by...Company's rupees 133–5–4 per mensem, to a consolidated salary of six hundred rupees per mensem, which will place him on an equality...with the Chief Civil Assistant of the Great Trigonometrical Survey."[3]

Increase was sanctioned to bring full salary to Rs. 500 only.

With SG. to Calcutta in Jan. 1861, remaining on duty here till granted sick leave to Nīlgiri Hills, leaving Calcutta 9–6–62. Writes to SG., 7–7–62 ; "I landed at Madras on the 14th and...started for the Neilgherries by rail on the 18th, 6 a.m. (taking advantage of the Wednesday's train which...runs the whole way through), and arrived at Coimbatore, 302 miles, at 10–40 p.m.

"The speed is not very first-rate, ... but the fares are very low, the carriage comfortable, refreshment rooms at not inconvenient intervals. ... I paid 1st and 3rd class tickets for self and servant, Rs. 17–3 for the entire distance which, with Rs. 6–4...for baggage, appeared very cheap when compared with the rates...on the Bengal side.

"Having a van, or transit as they are...called here, drawn by a pair of bullocks to carry me and bag and baggage, I left Coimbatore at 6 a.m., for Metapollium travellers' bungalow at the foot of the hills (37 miles), arriving there at 4 p.m., a slow and dear conveyance (Rs. 17 for the trip).

"At daybreak next...I was carried up to Coonoor, 15 miles in a 'muncheel', a sort of hammock borne by 8 bearers, not an uncomfortable thing, tho' much dearer (Rs. 8–14) than the jhampan of Mussoorie, which is not forthcoming in these parts. I should have preferred riding up, but my leg was not in the best state for horsemanship, even if the charge of Rs. 8 (!) for pony hire was not a sufficiently deterring cause.

"Coonoor is a well-sheltered, pretty, nook, with a comparatively mild climate, and many people sojourn in it for the greater part, or the whole, of the season. With Ootacamund, however, ...so near, and the difficulty of procuring lodgings at Coonoor, I quitted the latter after a couple of days halt at the travellers' bungalow, riding in to Ootacamund via Jackatala, or Wellington, where splendid barracks have been built for European troops, on the 22nd. A very delightful trip on a fair sunshiny morning. ... Here I have resided ever since. ...

"Having been at Mussoorie and Darjeeling, I am naturally led into comparisons. ... If the Neilgherries are considered prettier, with an endless succession of beautifully rounded hills from 6 to 8,000 feet elevation, and smooth sloping valleys with bits of table-land ever and anon, those highlands of the north-west and Bengal present in their ruggedness bolder and more scenic features, and the view...is grander with the snowy Himalaya on the one hand, and the wide expanse of plain on the other.

[1] Eur. letters, I (86), to JTW., 24–4–68. [2] DDn. 663 (209), GE. to CD., 1–6–57 ; 643 (192), ASW. to GE., 29–7–57. [3] DDn. 643 (273), ASW. to AG. Ft. Wm. 20–1–59. [4] incl. rev. srys., Bengal, of which he was the ultimate prof. authority [388, 537]. [5] *Geo. Mag.*, 1878 (68). [6] incl. up-country allce. [IV, 333]. [7] DDn. 643 (229), to Mil. Dept.

"Ootacamund is prettily embosomed in the midst of a number of rounded knolls, backed by higher eminences. It can boast of a charming 'lake', ... with a delightful ride and drive of about 6 miles round. There are also other roads...and a well laid out handsome botanical garden. Some of the flowers here are surprisingly beautiful. The heliotropes, ... fuschias, make their appearance as large trees...such as I have never seen before, but I miss many noble forest trees, ... pine, the oak, the rhododendron. ...

"I am putting up at the Union Hotel (late Dawson's), the best in the place, now kept by a Mr. Sylk. ... The charge is Rs. 5 a day. The fare and appartments are good. ...

"I have been progressing as respects health since I left Calcutta. ... I found the voyage very refreshing and invigorating, but I had taken with me on board some ugly boils... on my legs, in a more or less troublesome form. These did not altogether disappear in so short a sea trip, but they soon visibly...commenced healing under the influence of change of air, and I am glad to say shortly after I reached Ootacamund they ceased to trouble me. ...

"When I first arrived here the weather was dry and bracing for about a week or so, and I regularly walked and rode from 15 to 20 miles daily without fatigue, ... but for the past few days, the monsoon having set in, there has been much drizzly rain accompanied by high wind, and I have unluckily caught cold, which makes me feel over again...all my old pains about the left shoulder and side of the chest, and keeps me miserably confined within doors. ... I have not, however, had occasion yet to call in the doctor. ...

"The climate is more equable here than at Mussoorie, and the fall of rain less, yet the place...is very damp and cold at this time of the year. ... What with age, aches, and ails, telling upon me, I think sometimes that perhaps...I should never be much the worse for a little more sunshine and warmth.

"After trying another fortnight or three weeks, ... I purpose (D.V.) going down to Madras, via Mysore, Bangalore, and Raipatoor[1], in transit vans, taking the rail at the last...for the remainder of the journey. ... Varying my excursion thus I shall have an opportunity of seeing something of what is considered the nicest slice of...the Madras Presidency. ... I hope...to secure a passage in the last P. & O. steamer for August, whereby I may arrive at Calcutta...before my leave shall have quite expired. ...

"Unless my health most seriously demanded it, I should have no reasonable object in protracting my absence. ... Inclination and duty would always urge me back to my post at the right time"[2].

Webb appears to have resd. some time after 1866. He never married.

WHITING, Francis. Ben. Engrs.
b. 1822. kd., Cawnpore, 28–6–57, in Vibart's boat.
2/Lt. 11–6–40 ... Capt. 1–8–54.
Son of Francis Whiting, merch. of London.
Conolly (89/204).
DDn. 415 (4); GO. GG. 11–8–43, appd. Survr. 2nd. cl., Canals & Forests, Sind, under Baker [192]; GO. 24–2–44, granted 10 mo. leave on mc. to visit Simla [401].

WILLIAMS, Edward Charles Sparshott. Ben. Engrs.
b. 27–3–31. d. 2–10–1907.
2/Lt. 9–6–48 ... Lt.-Col. 10–12–73 ... Gen. 1–4–95.
Son of John Williams, surg., of Southsea, and Elizabeth his wife.
ed. BN. sch., New Cross, Deptford; Addiscombe, 1848, Pollock Medal; Chatham.
m., 1st., Rangoon, 9–6–55, Maria, dau. of Col. Elliot Voyle (1765–1834), Ben. Inf., Hodson, IV (360); she d., Calcutta, 23–3–57.
m. 2nd 1860, Charlotte Clementina, dau. of Thos. Bruce of Arnot, co. Kinross, Scotland; she d. 1872, their son, b. 24–7–65, became M. Gen. Sir Hugh Bruce-Williams, of RE, KOB.; DSO., and d. 14–12–1942.
CIE. 1878; KCIE., 1893.
Ubique; Conolly 91/261); *DIB.*; *Who Was Who*; Sandes, II (376).

1852–3, Burmese War; capture of Martaban, Rangoon, Prome [538].

GO. FD. 4–11–53, appd. to ch. Pegu Svy., holding ch. till 26–9–56; April 1854, consulted SG. and based svy. on traverse net, trgn. being impracticable [195–7, 282, 324, 384, 400].

June 1854, suggested improvements to tel. time signal to Ft. Wm. [140]; Sept. 1856, appd. Prcpl. of Civ. Engrg. Coll., Ft. Wm., opened at Writers' Bdgs. from 1–11–56, holding ch. till furl. on mc. 1859; 1860, to ch. Thomason Coll., Roorkee till relieved 1863.

1863–9, Under-Sec. PWD.; 1869–97, with Rlwy. Br., Simla and IO.

WILLOUGHBY, Edward Henry. Ben. Art.
b. 17–1–31. d., Brighton, 27–7–60, from wound of 23–7–57, at storming of fort nr. Saugor.
2/Lt. 14–6–50 ... 2nd. Capt. 27–8–58.
Son of Geo. Thos. Railton Willoughby, solicitor, and his wife Harriet Susan.
m., Saugor, 26–11–57, Fanny M., dau. of Lt.-Col. J. D. Wilson (1806–80); Ben. Inf.; Hodson, IV (494–5).
1853–4, asst. engr., Canal Dept., NWP.
11–9–54, appd. Asst. Rev. Survr., Saugor, under John Blagrave; 1857, succ. to ch. on his death [268, 400, 492].
July 1857, on temp. mil. duty, blew up gate of Ft. Balabetta, sustaining double fracture of leg; 17–3–58, furl. on mc. till death [396–7].

WYATT, Alexander [III, 372; IV, 398].
Rev. Survr., uncov.
b., India, Jan. 1807. d., at sea, 8–12–57.
appce. rev. Survr., 26–12–22; sub-asst., Dec. 1827; disch. Nov. 1842; re-emp. as Asst. Rev. Survr., in ch., 8–10–44; Rev. Survr., 1–10–48.
Son of Surg. Gen. Nevill Wyatt (d. 1817), Ben. Med.
ed. Upper Orphan Sch., Kidderpore; hd. scholar, 1822.
m., before 1846, Sophia; a son, Alex. Geo., b. 1845 appd. Topo. Svy., 1–11–61.
1822, appd. appce. survr. by Collr. Morādābād on Rs. 150; tr. Dec. 1827, to Rev. Svy. Dept. as sub-asst. and emp. under Birnie Browne till disch. on reduction of Dept. Nov. 1842 [III, 366; IV, 221; V, 396].
Nov. 1842 to May 1843, Asst. Supt. "family domains" of Rāja of Benares; 1843–4, Patrolling Offr. with Azamghar Customs Dept.
8–10–44 to ch. rev. svy. Sāran Dist.; emp. at intervals between 1845 and 1848 on svy. of Champāran-Nepāl bdy. [5, 185, 352].
Embarrassed by exchange of gifts on meeting the Nepāli Comnr., who "produced a khookree, a khanrah, and a couple of bags of musk as presents for me from the Durbar. Coming from such a quarter I could not but accept of them. ... In return I presented the Captain with an English sword with steel scabbard and belt; a piece of *khimkhap* brocade, and a gold-edged Benares putka. These were apparently much approved of by the Captain, who readily accepted of them, and has forwarded them, I understand, to the Maharaja".
Asked DSG. how to dispose of these gifts[3].
With hdqrs. at Patna, extended svy. eastward to cover Tirhut or Muzaffarpur, and then at end of

[1] Tiruppattur (50) m. sw. of Vellore. [2] DDn. 30 (1025). [3] DLR. 36/31 (12), 11–12–45.

1849 took party to Dacca for svy. of Mymensingh and Dacca dists. [6, 241–3, 251–4, 302, 437–8, 450].

Under CD. to B., 21–2–55, granted special increase of pay, Rs. 100, "for his meritorious services" bringing his allces. to Rs. 726 pm., the DSG. commending him as "a first-rate linguist; ... zeal and energy never flag; ... never at a loss—always commands a successful season without enlarging on difficulties... with whom it is always a real pleasure to do business"[1].

Dec. 1856, broke down with a stroke, his bro. Geo. writing, 1–1–57, from Bareilly that he had heard that "my brother... has been very seriously ill...[and is] in a very precarious state, ... paralysis". He obtained 3 mo. leave on mc. and left fd. hdqrs. in Mymensingh Dist. on 16th Feb. sailing from Calcutta 29th April; granted an extension of 6 mo. He wrote from Penang 7–6–57, and d. six months later whilst still on leave.

YOUNG, Ralph. Ben. Engrs.
b. 28–11–25. d. 9–11–97.

2/Lt. 7–6–44 ... Col. 1–3–75; ret. as M. Gen. 4–7–77.

Son of John Adolphus Young, of Maidenhead, solicitor, and Frances his wife, dau. of Wm. Haggard, of Bradenham, Norfolk.

Addiscombe. Conolly, 90 (253).

GO. 15–4–46, appd., with Robinson [208, 524], asst. to James Abbott, Comnr. for settling N. border of Punjab, "for surveying...a belt of country 12 miles broad from Kangra to the Indus, and including the boundary which was traversed. This we finished in June '47, when I received orders to leave that business to my partner Robinson, and proceeded to join Mr. Agnew, C.S., in an expedition across the Himalayas to Gilgit" [187].

"From this I have just returned, and am now...making a map of the states which I visited. ... I was first mathematician of my term at Addiscombe, and have read something of astronomy since I arrived in India. I have passed two rainy and two hot seasons in tents, and can stand a great deal of hard work and roughing".

He applied for appt. to GTS., which could not be arranged[2].

YULE, Henry. Ben. Engrs.
b. 1–5–20. d. 30–12–89.

2/Lt. 11–12–38 ... Col. 14–6–62; ret. 24–6–62.

Son of Maj. Wm. Yule (1764–1839 (, Ben. Inf., Hodson, IV (555), and Elizabeth, dau. of Wm. Paterson, of Brachead, his wife; bro. of Sir Geo. Udny Yule (1813–86), BCS., KCSI, CB., *DNB.*; *DIB.*

ed. Edinburgh High Sch.; Addiscombe and Chatham.

CB. 1863; KCSI. 1889; Presdt. Hakluyt Soc. 1877; LLD. Edinburgh, 1883; Presdt. R. As. Soc. 1885; FRGS. and gold medal.

DNB.; *DIB.*; Conolly (89/199); obit., *JRGS.*, XII, 1890 (108–13).

arrd. India 1840; 1840–4, Asst. Delhi canals under Baker.

1843, on svy. Khāsi Hills, SK., for coal tramway from Cherrapunji, *IO Cal.* (303).

1845–6; 1st Sikh War; 1846–8, Ex. Engr. Ganges Canal 1848–9, 2nd Sikh War; 1849–52, furl. to Scotland.

1852–3, on recce. of passes Arakan–Burma frontier [194–6]; Report pub. with map, *Roorkee Papers*, I, 1863–4 (1–28); map, MRIO., 157 (8); *IO Cal.* (304–5); 1855, Sec. to Phayre's mission to Ava; report on map read before RGS., 26–1–57, *JRGS.*, XXVII, 1857 (54–108); Pegu area "taken from a large map by Lieut. Williams [196, 543]".

Sec. to Govt., PWD.; IO. Council, 1875–89.

Prolific writer on Geography of Central Asia and Indian borders [540]. Pubns. incl. *Narrative of the Mission to the Court of Ava*; *Cathay & the Way Thither*; *Book of Ser. Marco Polo* [240]; ed. John Wood's *Journey to the Source of the Oxus* [IV, 280–1]; Joint auth. of *Hobson-Jobson* [1; XVIII]; contributed many articles to *Ency Brit.*

[1] DDn. 624 (20), 2–5–56. [2] DDn. 463 (743), to SG., 22–11–47.

INDEX

[NAMES LISTED IN BIOGRAPHICAL NOTES AND MANY OF THOSE IN NOMINAL ROLLS, ARE NOT REPEATED HERE]

Abbott; James (1807–96), Ben. Art. [IV, 416–7]; *DNB.*; *DIB.*; x, 187, 208–9, 258, 456, 524, 544:—Saunders Alexius (1811–94), Ben. Inf. [IV, 417]; *DNB.*; *DIB.*; 269–70, 435, 529.
Abbottābād, Hāzāra, 208.
Abyssinia, or Ethiopia, 527.
Abercrombie, Wm. (1812–58), Ben. Engrs., 1828–57 [IV, 269], Supt. Roads, PWD. from 1836; Conolly (88/163); 309.
Absconders, 437, 443.
Absence without leave, 424, 427, 435, 441, 443.
Abu-l-Fazal, 'allami (the learned) (1551–1602) [I: 133], auth. Ain-i-Akbari, 240.
Abu, hdqrs. town, Rājputāna, 38, 41, 54, 72, 438, 533:—merdl. ser., 54, 57, 60, 72, 103, 192, 523; v. Mt. Abu.
Abu Zaid, Arab geographer, 240.
Accidents, 24, 206, 210, 340, 446, 454, 517, 525 v. Instruments.
Accountant, 353, 365, 542:—General, 346.
Accounts, 166, 452.
Accuracy, or precision:—GTS., t page, 10–11, 14, 34, 54, 76, 97, 102, 114–7, 130, 135–7, 229, 231, 281, 338, 340, 390, 392–5, 417, 497, 503, 514, 520:—Compns. 127, 132:—Geogl. Positions, 92, 225, 519, 532:—Heights, xiii, 62–3, 75, 92, 94:—Maps, 147, 214, 297, 342, 346, 427, 541:—Rev. Svy., 247, 251, 258, 261, 272, 292–3, 303, 346, 396, 536:—Spirit Levelling, xv, 76:—Topo. Svy., 5, 168, 176, 179, 187, 211–2, 189, 193, 216, 229, 281–5, 421, 506, 524, 539, 541:—Trgn., 286, 385, 426.
Acquittance Rolls, 453.
Acre, unit of area, 302–4.
Adam, John (b. 1818/9); civ. asst. Rev., 433–4, 437, 439.
Adams:—Fredk., civ. asst. Topo., 430:—Geo., junr. (1750–95), instr.-maker, 297:—Lieut. 145, 430, 448:—John Couch (1819–92), mathn., Camb.; 502.
Addiscombe Coll., 291, 388–90, 397, 490–544, *passim*.
Adjutant, 492, 541:—General (AG.), 339, 511.
Administration:—Civ., 258:—Deptl., xv, 336, 537, 541; v. Lahore.
Administrative:—Control, xiv, 172, 433–4:—Divs., 188, 285, 313–4, 499:—Duties, 538:—Hdqrs., 243:—Offrs., 470.
Admiralty, British, 324.
Afghān:—People, v, 208 n.7:—Wars, 1839–42, x, 5, 379, 433 n.1, 495, 536, 542.
Afghānistān, 448:—Boundary, 47 n.4:—Maps, v.
Afridi tribesmen, 47, 215, 474–5, 539.
Agent to GG. (AGG.):—Central India, 289:—NE. Frontier, 29, 311:—NW. Frontier, 269, 316:—Rājputana, 191, 266, 500:—SW. Frontier, 526.
Agnew, Patrick Alex. vans (1822–48), BSC. *DNB.*; *DIB.*; 186–7.
Agra:—Arsenal, 149, 152, 158, 162:—City, 309, 316, 371, 438, 483, 541:—Capital of NWP., 314:—Dist., 190:—Rev. Bd., 349:—Svy., 309.
Ahmadābād, Gujarāt, 54, 57, 60–1, 192, 523, pls. 1, 3, 28.
Ahmadnagar, Bombay, 55, pls. 1, 3:—Rev. Svy., 276, 398–9, 488, 494–5, 497, 521, 523.
Aide-de-Camp (ADC), 488, 494.
Ain-i-Akbari [1: 133 n.1], 240.
Airy, Sir Geo. Biddell (1801–92); FRS. 1836; AR. 1835–81 [III, 517; IV, 477]; *RAS* (*mn*) 52 (212). *RGS. Progs.* LL., 1892 (1–xxi); KCB. 1872; *DNB.*; 125, 135, 137, 503, 520, 530, 535, 540.
Ajanta caves, Aurangābād Dist. 177; pls. 1, 28 (Adjunta).
Ajmer, Rājputāna, 3, 50, 51, 54, 56, 191, 438, 523; pls. 1, 3, 16, 28:—Rev. Svy. 50, 56, 265–6, 294, 364, 396, 435–6, 494; 505, 539 v. Merwāra.
Akbar (1542–1605), Emperor of Delhi [1: 10, 71], 231.
Akyab, Arakan, 243, 534, 538; pl. 1.
Algebra, 446, 501.
Aligarh, NWP., 337, 374; pls. 1, 3, 4, 5, 28 (Allygurh).
Allipore, Calcutta, 24, 183, 249.
Allahābād, NWP., 11–2, 15, 23, 122, 142, 164–5, 167, 184, 337, 361, 368–9, 371, 374, 409, 438, 483, 499, 501:—Church, 439:—Recess qrs., 15 18, 22, 122, 126, 130, 410, 458, 521, 530:—SG's. Hdqrs., 122, 308, 336, 341, 458, 496, 498, 504, 541–2.
Allan, survr. in Burma, 196.
Allen, W. & H., cartographers [IV, 477]; 307, 316.
Allom, Chas. Edwin (1827–49); Bo. Art.; MI. Peshāwar, 216.
Allowances & Salaries:—Acting, 536:—Boat, 434:—Dmp., 353:—Fd. Parties, 38, 362:—GTS. 38, 379–82, 387–8, 398–9, 407–8, 490, 506 n.6, 533:—Civ. Assts., GTS. 31, 362, 403–9, 429:—Hill or Mountain 85, 347, 363, 375–6, 399–400, 429–30, 479, 486:—Mil. Topo. Assts., 489, 513, 518:—Personal, 358, 398–9, 506, 516, 525–7, 536:—Bo., 398–9:—Special, 142, 145, 527–9, 537:—Topo. 175; v. Charge; Contract; Dandy:—Up-country, [IV, 123, 477], 522, 542 n.6; v. Mil.; Salary; Travelling.
Almirahs, map, 352.
Almora, Kumaun, 324; pls. 1, 3, 28.
Alps, of Europe, 144, 205, 527.
Alum, 466.
Aluminium, 151.
Alves, Chas. Geo. (1786–1862); Mad. Inf. [II, 376], 195.
Alwar, Rājputāna, 50, 309; pls. 1, 3 (Ulwar), 5, 16, 28.
Amarkantak, CP., 521, 528; pl. 28.
Ambāla, Punjab, 79–80, 210, 269, 434, 436, 505, 509; pl. 1 (Umballah); 3, 5, 16, 28:—metl. obsy., 139:—Rev. Svy., 7, 269–70.
Ambela campaign, NWF., 1862–3, 488, 509.
America, 437, 505.
American:—people, 504:—text-books, 297.
amins, land measurers, 201, 244–6, 263, 268–9, 272, 277, 293, 299, 304, 450–1, 501:—Assam, 312:—*parāl*, 451; v. India.
Amplitude, celestial, 43, 469; v. Arc.
Amraoti, Berār, 178, 517.
Amritsar, Punjab, 222, 302, 316, 337, 375, 477, 505; pls. 1, 3, 5, 6, 28:—position, 314:—Rev. Svy., 272–3, 513; v. Treaties.
Amsot HS., Western Dūn, 34, 98, 124; pl. 6.
Amua merdl. ser., 1, 16, 84, 125, 309, 541; pls. 3, 4.
Andaman Is., 416, 509.
Aneroid barometer, 69, 85, 91, 112, 116–7, 122, 126–8, 198, 210, 214.
Angle-books, 87 n.6, 89, 285, 290, 320, 446, 534.
Angles obsd., 25–7, 49–50, 56, 84, 99–100, 116–7, 121, 541:—means deduced, 117, 121, 385, 409:—register, or copy, 394, 497, 530.
Anglo-Indian; v. East Indian.
Angul State, Orissa, 144, 169–70, 175, 525; pl. 1 (Ungool).
Anicut, masonry dam [1: 95 n.6, 107], 519.
Apologies, 394–5, 413, 497, 522, 526, 530–1.
Apoplexy, 76.
Apothecary, or medical asst., 168, 173, 183, 367, 464; v. Doctors.
Apprentices; Rev. Svy., 433, 435.
Approximate Series, GTS., 3, 17–8, 99–100, 113–4, 120–1, 148, 156, 160–1, 404, 409, 416:—Assam, 30–1:—Bombay, 55–7, 59–61, 103, 523:—East Coast, 25–9, 113:—Gt. Indus, 44–6, 48–9, 76, 540:—Gt. Longl., 38–9, 41, 523:—Kashmir, 222–3, 226–7, 232–3, 506:—NE. Longl., 84:—Punjab, 50, 52–3, 111, 484.
Arabs, 240, 478.
Arakan, Burma, 165, 194, 198, 495, 538; pls. 1, 16:—Coast, 195:—Frontier, 544:—Rev. Svy., 243–4, 349, 433–4, 438:—Yomas, 194, 196, 198, 434, 490, 498, 544.
Aramlia merdl. ser., Rājputāna, 3, 5, 50–1, 54, 56, 315, 523; pl. 3.
Aravalli Hills, Rājputāna, 2, 38–9, 99, 120, 406, 467, 523; pls. 1, 28, Aruwalli.
Arc:—Books, Everest's, 1830, 1847 (*Merdl. Arc.*), xlii, xvi, xxvi, 132 n.5, 135 n.6, 530:—of meridian 125, 130, 133, 135:—of parallel, 125, 130, 136.
Archæological Svy., 451, 518.
Archæology, 264, 324, 498.
Archdeacon, Calcutta, 136, 520, 541.
Architectural drawing, 437.
Archives of India, National, (NAI) xvi, 270, 305, 347.
Arcot Dist., Madras:—N. vii, ix:—S.; Rev. Svy., v, 8–9, 279–80, 503, 521.
Area:—British India, 307–8, 346:—of Provinces, 195, 220, 345–7:—found by Rev. Svy., 293–4, 450, 501, 535:—of Estates, 244, 251, 259, 292–3:—fields, 300–2:—villages, 8, 251, 264, 272, 293–4.
Arithmetic, 446.
Armed:—Force, 292:—Marauders, 485; v. Assaults.
Arms:—for defence, 216, 449, 482:—Mil. weapons, 377, 477, 484.
Armstrong, John Wm. (b.c. 1–9–13); Civ. Asst. GTS. [IV, 384]:—trgn. Ganges valley, Bihār, 11–3, 18, 90, n.4, 101–3, 126, 155–6, 337, 361, 366, 368–9, 410, 457–8, 541:—obsns. to Pk. xv., 17, 82–5, 91–3, 95–6:—trgn. Punjab & Gt. Indus, 46–50, 53, 110–1, 44, 509, 534, 540:—promotion, 402–3, 408, 415:—related to Hennessey, 418, 501.
Army:—British, 483:—Hdqrs., 386.
Arnold, John (1736?–99) & Dent, Edw. John (1790–1853); inst. makers, London; both *DNB.*, 163.
Arrowsmith, John (1790–1873), FRGS.; *DNB.* [IV, 417]; cartographer, vii, x, 307, 317:—Maps of S. India, vii, 319.
Arsenals & Magazines:—Regtl., 485:—Allahābād, 164–5, 435:—Chunār, 164:—Ft. William, 165:—Karāchi, 151; v. Agra.
Artificers and artisans, 107–8, 140–1, 222:—Calcutta, 165–6, 358.
Artillery:—Bengal:—Officers, 10, 171, 175, 192, 194, 196–7, 384, 386, 390, 397, 495–543, *passim*:—Bombadier, 164, 358, 360:—Bombay, 215:—Depot, Dum Dum, 536:—Horse, or Garrison, 498, 528, 535:—Madras 527:—Units, 527, 538.
Artistic drawing, or painting, 229, 488–90, 511, 629.
Artists, 146, 171, 191, 239, 428, 499, 515–6, 529.
Asiatic Soc. of Bengal, 94–5, 140, 142–3, 146, 265, 329, 440, 443, 481, 492, 509, 529, 536–8:—*Journal of* (*JASB*), xxvi, 187, 526, 529.
Ass, or donkey:—Domestic, 406, Wild, or *kyang*, 219 n.3, 235, 481.
Assam:—Allowance, 31, 362, 406:—Climate, 30–1, 393–4, 415, 461–2, 510:—Difficulties of svy., 362:—Dist. svys., 312:—Elephants, 373:—S. Frontier, 253:—Geog. Svys., xiv:—Govt., 32:—GTS. Party, 344, 482, 541:—Longl ser. GTS. xiv 2, 16, 20, 29–31, 64, 85–6, 99–100, 105, 120, 132, 153, 155, 207, 312, 337–8, 345, 361–2, 369, 373–4, 379, 393–4, 407, 415–6, 468, 471, 483–4, 496, 510, 519, 541:—Lower, 29, 242, 467:—Lt. Inf., 183:—Maps, 308, 311–2:—Rev. Svy., xiv, 241, 349, 372:—Sickness, 461–2:—Snow Peaks, 85–6:—Transport, 362, 371:—Upper, 145, 194, 242:—Valley, 362, 448:—Waste Lands svy., 416.
Assamese peoples, 31, 377, 454–6 462 n.2, 471, 473–6, 485–6.
Assaults:—Armed, 176–9, 219, 230, 473–6, 489, 500:—Mil., 339:—& bullying by Surveyors, 321, 413, 432.
Assessment of revenue, 6, 242, 246, 258, 271–2, 275, 279–80, 292–3, 299, 398, 471:—fd. by fd., 276, 491.
Assistant:—Personal, 342, 349, 388, 408, 417:—SG.; Hdqrs., 70 n.3, 353, 414, 511:—in ch. Madras Topo. Party, 30–6, 429, 500, 525; v. Comprs. Rev. Survr.
Assistants:—CIVIL:—GTS., xiv, 10, 100, 342, 381, 388, 402–20, 511:—Rev. Svy.; BENGAL, 10, 192, 241–2, 268, 305, 365, 499–500,

433–44, 411 :—Hd. Asst., Hdqrs., 352–3, 435, 440–1 :—BOMBAY, 192–3, 276–8, 444–5 :—Madras, 445 :—Topo. Svy., 10, 201, 211, 421–32 ; v. Europeans, Hdbd. :—MILITARY :—GTS. 380–2 :—Rev. Svy., Bengal, 242, 256, 305, 365, 396 :—Bombay, 398, 400–1, 525 :—Madras, 401 :—Topo., 169, 171–2, 208, 225, 227, 280, 384, 386, 389, 399–400 ; v. Nominal Rolls.
Asthma, 236, 237, 503.
Astor, Kashmir, 187, 277, 481 ; pl. 6.
Astronomer :—Colāba, 139 :—Madras, 51, 139, 380, 534, 540 :—Royal, Greenwich (AR), 135, 530, 535, 540 ; v. Airy ; Gill.
Astronomical :—Asst., GTS., 127, 341–3, 379–81, 403, 410, 417, 511, 515, 523, 532, 540 n.4, 541 :—Circles, 130–1, 152 :—Clock, 130–1 :—Comps., 503, 507 :—Obsns., 15, 28, 46, 55, 130–3, 136, 167, 204, 281, 314, 337, 351, 380, 416–7, 503–4, 507, 515, 535 :—Observr., 532, 534 :—Party, 519 :—Svy., 181 :—Tables, 124. v. Insts. ; Transit ; Time.
Astronomy, science, 136, 503, 518, 533–4, 544.
Atkinson :—David (b. May, 1837), civ. asst., Topo., 173, 176, 422, 428, 430, 464 :—Geo. Wm. Elliott (b. Oct. 1843), civ. asst., GTS., 234, 418 :—Henry McArthur (b. c., July 1842), 430.
Atlas of India, 1-inch, xlii, xv, 9, 22, 68–9, 86, 180, 187, 190–1, 214, 239, 281, 289–90, 307, 314, 316–9, 385, 520, 537, 540 :—criticised, 311 :—sheets under pubn., 176, 266, 308, –11, 346, 540 :—reaching India, 310, 324 :—pubn. in India, xlii, 9, 537 :—sale-price, 323, 326 :—use of rev. svys., 295, 306, 310–2, 337 ; v. Projection.
Atlas :—Himālaya, 319 ; pl. 6 :—*N. Frontier*, 531 :—Orissa by Saxton, 527 :—Schlagintweit, 146 :—South India, 319.
Atmosphere :—clear, 18, 28–9, 40, 366 :—thick, 12, 14, 28–9, 38, 54–5, 114, 467–8, 490.
Atmospheric conditions, 256 ; v. Refraction.
atta, wheat flour, 208, 453, 479, 517.
Attock, Punjab, xv, 2, 34, 36, 44, 153, 200, 215, 221, 337, 423, 490, 505, 511, 515, 532, 541 ; pls 1, 3, 5, 9, 28 :—Dist., 887 n.1 :—Bridge, x, 43, 517, 532 :—Fort, 42 :—Geographical Position, 317.
Attraction :—local, 102, 125, 132, 503, 520–1 :—Himālayan or Mountain, 10, 66, 92–3, 102, 124–5, 132–8, 204, 234, 337, 391, 530, 541 ; v. Deflection.
Audit Dept., 346.
Auditor-Gen. :—Civ., 347, 376 :—Mil., 166, 407.
Aurangābād, Deccan, 179 ; pls. 1, 3, 28.
Aurangzeb, Mughal Emperor of Delhi, 1658–1707, 240.
Austen, Robt. Alf. Cloyne Godwin (1808–84), geolgt. ; *DNB.*, F.R.S. ; FGS. ; 488.
Australia, 430, 509 :—leave to, 442, 497, 504, 518–9, 524.
Author & writer, 498, 503, 512, 520, 544.
Autograph, 489, 523.
Auxiliary Tables ; dptl., 10, 1 2–3, 128, 355, 516, 521–2.
Ava, Burma, 194, 544.
Azamgarh, NWP., 12 ; pls. 1, 3, , 16, 28 :—Rev. Svy., 510.
Azimuth, astr. :—Angle, from merdn., obsn., GTS., 11, 17, 23, 25, 29, 38, 40–1, 97–8, 102, 109, 120, 128–36, 170, 215, 246, 286, 410, 525 :—Comps., 121–2, 126, 282, 290 :—Rev. Svys., 251, 265, 298, 448 :—Initial value, GTS., 124–5 ; v. Circle.

Babbage, Prof. Chas. (1792–1871), mathn. ; FRS. ; *DNB.* ; 123–4.
Babonau, Henry (1765–1834), Asst. Commy. Ordn., 501.
babu, respectful Bengali desgn., 410, 501, 514.
babul, *acacia arabica*, 41, 48.
Badrināth, Kumaun, 81, 145 ; pls. 1, 3, 28.
Bagay's Logarithm Tables, [IV, 478] 124.
Baggage :—Surveyors', 73, 162, 222, 278, 371, 413, 514, 518, 527, 542 :—Transport for, 24, 35, 57, 278, 371–3, 406, 450, 480.
Bahāwālpur, Rājputāna, 46, 53, 191, 193, 324, 534 ; pls. 1, 3, 5, 16, 28.
bajra, *pencillaria spicata*, Indian grain, 40.
Bākarganj, E. Bengal, rev. svy., 243, 256, 364, 499, 531 ; pls. 1, 3, 4, 16, 28.
Baker :—Alfred & Arthur, both civ. assts., Bo. Rev. Svy., 444 :—Gen. Sir Wm. Erskine (1808–81), Ben. Engrs. [IV, 417] ; KCB. ; *DNB.* ; *DIB.*, Hodson, I (80) ; x 8, 192–3, 266, 512, 538, 543–4.
Balasore, Orissa :—GTS., 2, 25–7, 71, 118, 468, 504, 525 :—Maps 311 :—Topo. Svy., 168–9, 172–5 :—Rev. Svy., 246 296 304, 434 :—Climate, 465–6, 468 :—pls. 1, 3, 4, 16, 28.
Baltistān, or Little Tibet, 89, 147, 227, 230, 232, 235–6, 239–40, 489, 513 :—people, 240 ; pls. 5, 13.
Baluchis & Brahuis, 45, 49, 100.
Baluchistān, ix, xi, 133, 316 :—border, 44, 193 ; pls. 1, 5.
Bamboo :—jungle, 28, 198, 283 :—rods and matting, 71, 150, 104, 106–7, 111, 247, 301 :—Scaffolds and poles, 25, 39, 118, 150, 198, 484.
Banda Dist. Bundelkhānd, rev. svy., 299 ; pls. 1, 3, 4, 16, 28.
Banderpunch ; Himālayan Pk. ; 20,720 ft., 81, 86, 137, 207 ; pl. 3.
Baness, Alex. Fredk., 213, 227 & Joshua Fredk. (1830–64), 343, 430 ; both civ. assts. Topo.
Bangalore, S. India, 543 ; pl. 28 :—Longl. Ser. GTS., 492 ; v. Base-lines.
baniahs, grain merchs., 465, 479–80, 517.
Banihāl : Pass, Kashmir, 222–4, 228, 424, 430, 490, 506, 514 :—River, 223 ; pls. 13.
banyan trees, *ficus elastica*, 478.
Banks, financial, 378, 437, 507.
Bānkura Dist., Bengal, 311 ; pls. 1, 4, 16, 28 :—Rev. Svy., 255.
Bannu, NWF., 4, 47, 210, 216–9, 317, 539 ; pls. 1, 5, 28.
Banog, HS., 7,429 ft., 21, 34, 63, 66, 69, 98, 124, 133–8, 200–1, 207, 520 :—Height, 21, 66, 238 :—Obsy., 81, 138, 238, 343, 523, 530.
Bara Lācha La, Himālayan Pass, 16,200 ft., 146, 186, 202–3, 205, 234–5, 286, 506, 509, 516–7, 528 ; pl. 6.
Baraitch, Oudh, 488 ; pls. 1, 28.
Bāramahāl, Salem, S. India, 8, 288.
Bāramūlā, Kashmir, 224, 228, 488, 490, 493, 506, 511 ; pls. 6, 13.
Bareilly, Rohilkhand, 258–62, 494, 544 ; pls. 1, 3, 4, 16, 28.
Bari, or *Rabi*, *dodb*, Punjab, 7–8, 37, 52, 210 ; pl. 16 :—canals, 77, 159, 500 :—Rev. Svy., 272–3, 296, 302, 316, 365, 397, 488, 492, 494, 497, 499, 535.
barkandāz, civil guards [IV, 41–3], 16, 35, 158, 212, 2 4, 251, 333, 365, 376–8, 454, 471, 478.
Barnard, Thos. (1746–1830), Mad. Engrs. [I : 311], 297.
Barnes :—Geo. (b. Nov. 1799) ; hd. writer [IV, 349], 352, 359 :—Geo. Carnac (1818–61) ; BCS. 1837 ; *OW.*, KS. 1881–5 ; 500 :—Kangra, 271, 272 n.1, 302 n.4.
Barnett, W. S. (b. 1822), asst. civ. survr., Burma, 198–9, 425, 430.
Baroda, Gujarāt, 55, 191–2, 375, 438 ; pls. 1, 28.
Barometers, 69–71, 145 n.6, 146, 158, 198, 228, 236, 363 :—Height obsns., 66, 69–70, 98, 140, 145 n.5, 203, 235–6, 238, 448 :—comp. obsns., vii, 139, 228, 344, 356 :—Experiments, 187, 523 :—Height value, 528–9 ; v. Aneroid.
Barometric pressure, 65, 139.
Barrackpore, Bengal, 22, 71, 106, 248, 484, 537 ; v. Base-lines.
Barrow, Henry (1790–1870), inst.-maker [IV, 417–9], FRAS., 148–50, 153, 155, 163–4, 290, 299, 358, 523 ; v. Theodolites.
Base-line Apparatus, 20, 42–4, 50, 97, 158–9, 162, 371, 509, 511 ; v. Pillars.
Base-lines :—chain-measd., 281 :—short, 160 :—GTS., 19, 44, 75, 79, 100–1, 109, 129, 149, 158–9, 281, 336–7, 417, ; pls. 2, 9 :—Bangalore, 18, 68–9, 502–3 :—Bidar, 20, 44 n.7, 541 :—Chach, 2–3, 34, 42–5, 50, 52, 66, 76, 79–80, 97, 150, 157–8, 208, 211, 221, 337–8, 344, 377, 383, 388, 417, 503, 505, 509, 511, 513, 517, 532, 539, 541–2 ; pl. 9 :—Calcutta, or Barrackpore Road, 2, 14, 19–20, 22–3, 44 n.7, 66, 70–1, 80, 469, 504 :—Cape Comorin, 159, 490–2, 503 :—Debra Dūn, 16, 19–20, 34, 43, 44 n.7, 80, 90, 124, 128, 137, 220 :—Karāchi, 3, 37, 41–6, 50, 97, 109, 158, 194, 221, 338, 344, 371–2, 383, 391, 417, 509–10, 512–3, 518, 532–4 :—Merrut, 1880–2, 492 :—Sironj, 19–20, 44 n.7, 67, 80, 124, 128 :—Sonakhoda, 2, 13, 15–7, 20–1, 29–30, 44 n.7, 66–7, 69, 71, 80, 90, 97, 158, 186, 336–7, 341, 379, 422, 501, 509–11, 520, 523 :—Vizagapatam, 29, 97, 159, 490, 492 :—TOPOGRAPHICAL, 192, 196, 208–9, 214–5, 259, 287, 337.
Basevi, Geo. (1794–1845), FRS. ; *DNB.* ; 490.
Bashahr State Upper Sutlej, 478 n.5, 479, 505.
Baspa R., Upper Sutlej, 207–8, 505 ; pl. 10.
Bates, traveller & geographer, 87.
Bath :—Companion of (CB), 509, 524, 536, 544 :—Somerset, 490, 494, 513, 516, 538.
batta, allowance, 450.
Batten, John Hallett (1811–8), BCS. [IV, 419], x, 86, 188, 318.
batwara, divn. of estate [IV, 187 n.5], 251.
Baxter, Chas, (1809–70), portrait painter, 525.
Bay of Bengal, 75, 80.
bazār, 479–80, 494 :—purchases, 165.
Beacons, coastal or river, 15.
Bearers or Carriers ; v. Porters.
Bearings, or azimuths, 82, 84, 160, 185, 265 ; v. Azimuth ; Compass.
Beās River, Punjab, 7, 34–7, 52, 200–2, 269, 271–2, 501, 516, 534 ; pls. 1, 3, 5, 6, 28.
Beaseley, Geo. Adam (1870–1961) ; RN. Connolly (66/1021) ; RN. 1897–1925 ; 227 n.2.
Becher, Arthur Milford (1818–87) ; Ben. Inf. ; AQMG, 1844–50 ; Sikh Wars, 1846–9 ; Hodson, I (114–5) ; 318.
Bedford :—Alex. [IV, 420] ; River Survr. xi, 15, 26, 71, 462 :—James senr. (1787/8–1871), Ben. Inf. [IV, 420] ; DSO., 1853–62 ; vii, xiv, 163, 241, 297 :—James, junr., civ. asst., Rev. [IV, 399], 242.
Beds, or charpoys, 459–60.
Beer, 411, 457.
beldars, or shovel-men, 253.
Bell :—Wm. (1811–71), BCS. 1830–60, Bupt. Rev. Svy., 242 :—Chas. R. (b. 1810/1), civ. asst. Rev. [III, 370] ; vii, 432, 439 :—Francis Archbd. John, (b. April 1842), civ. asst. Trig., 418 :—Robt. Arthur (1834–67), civ. asst. Topo. 180, 211, 213, 227, 229, 234, 424–6, 427–8, 480 :—Wm. E., civ. asst. Bo. Rev., 444.
Belletty, Nich. Alex. (b. Sept. 1828), civ. asst. Trig., 12, 43 n.2, 44 n.2, 47 n.2, 49, 165, 403–4, 406, 410, 418.
Benares, NWP., 12, 15, 299, 315, 336–7, 341, 369, 371, 410, 437, 499, 510, 520 :—College, 432 :—Rāja of, 543 ; pls. 1, 3, 4, 16, 27.
Bench-marks, 53, 68, 70, 74–9, 183, 260, 263 :—Standard, GTS., 68.
Bengal :—*Alm. & Directory*, 324 :—*Atlas*, Bennell's [I : 227–30], 312, 322.
Bengal :—East, 5, 132, 308, 434 :—Estbt., 251, 398–9, 429 496, 526 :—168–9, 183 :—Govt. 329 :—*Lower Provs.* (LP), xiv :—Service 107, 243, 294, 320, 349, 364–5, 368 407, 433, 478 :—Presdt. in Council, 349, 355 :—SG., 1767, xiii :—Trgn., xiv, 101 ; v. Climate ; Tigers.
Bengali ; v. Computers ; Dmn.
Bennett, W. E. (Ld., Jhānsi 8–6–57), civ. asst. Rev., 271, 439, 483 n.1
Bentinck, Lord Wm. Cavendish (1774–1839) ; GG. 1827–35 ; *DNB.* ; *DIB.* ; *Ency Brit.* [II, 460 ; III, 518 ; IV, 478], 281, 408.
Berār, Hdbd., Deccan :—v. Rev. Svy., Topo. Svy., pls. 1, 3, 28.
Berhampur :—Bengal, 14–6, 361, 372, 487, 499 ; pls. 2, 4, 28 :—Ganjam, 28, 167, 370, 466, 500, 525 ; pls. 1, 28.
Berlin, Geogl. Soc. ; Gesellshaft fur Erdkunde ; 339–40.
Berrill :—Henry James (1835–57), ix, 418, 461 :—Thos. Alex. (1830–57), 15 n.7, 16, 18, 30 n.5, 31, 418, 461 : both civ. asst. Trig.
Bessell, Freidrich Wm. (c. 1784–1846), German Astr., *Ency Brit.*, 128.
Bettiah, Champaran Dist., 13, 251–2 ; pls. 1, 28.
Beverley :—Henry (1838–80), 31 n.2, 32–3, 50 n.5, 371, 418, 466 :—Wm. Geo. (1835–82), 8, 90 n.4, 225, 227–8, 230, 232, 234–7, 404, 410 n.3, 418, 423, 514 : both civ. asst. Trig.
bhabur, submontane gravel slope, Oldham (457–8), [IV, 473], 259, 281.
Bhāga R., Lahūl ; v. Chandra-Bhāga.
Bhāgalpur, Bihār, 13, 118, 245, 337–8, 369, 374, 456, 522, 541 :—Dist., 314, 324, 454 ; pls. 1, 3, 16, 28 :—Rev. Svy., 6, 241, 245, 254, 434, 505, 510, 520, 529, 538.
Bhāgirathi R. :—Lower Bengal, 312, 372 :—Upper Ganges, 206–8, 422.
bhar, Punjab, or *thal*, Rājputāna, desert land, 2, 47, 52, 216, 273, 294.
Bharatpur, Rājputāna, 190, 309 :—Rev. Svy., 266–7, 364, 452, 538, 453, 500 ; pls. 1, 3, 5, 16, 28.
Bhil tribesmen [I : 126 ; II, 168 ; III, 518], 38–9, 56, 473 ; v. Meywar.
Bhola Nāth Mazumdhar, compr., 344, 354–6, 360.
Bhopāl, Mālwa, 189–90 :—Contt., 376 :—Resdt., 188 ; pls. 1, 3, 4, 5, 16, 28.

Bhōl Gulāb, 59–60, 518 ; pls. 1, 3, 5, 28 (Bhool).
Bhūtān, Himālaya :—Frontier, 509 ; mission of 1864, 489 :—Peaks, 85 :—War of 1865, 538 ; pls. 1, 4, 16, 28.
Bidar, Hdbd, xiv, 54, 66, 72 :—Longl. Ser., GTS., 28 n.4 ; pl. 3 ; v. Baselines.
Bihār :—City, 13 :—Dist., or Baya, 142, 241, 255, 299 ; pls. 1, 3, 16, 28 :—Province, 82, 185, 241, 243, 257, 306, 395, 397 :—Maps, 326 :—Plains of, 94 :—Rev. Svy., 5, 6, 295, 349, 395, 433, 436–7, 504, 529 :—Trgn., 1, 83, 337, 368, 541.
bigha [IV, 208 n.1 ; one sq. *jarib* of 80 *hāth*], about ⅓-acre, 138, 186, 302–4, 451.
Bīkaner, RĀjputāna, 51, 191, 492, 496 :—Desert, 52 ; pls. 1, 3, 5, 16, 28.
Bilāspur :—Simla States, 186, 200–2, 206, 474, 517 ; pl. 6 :—Merdl. Ser., CP., 510 ; pls. 3, 4.
Birbhūm Bengal, Rev. Svy., 6, 241–2, 254–5, 456, 529 ; pls. 1, 16, 28.
Black :—Chas. Edw. Drummond (1845–1917), India Office, 1869–92 ; xxv, 533 :—Alex. (d. 1859), topo. dmn., 428, 430 :—Thos, [IV, 267 n.9], printer, Calcutta, 185.
Black :—Mtn. mil. expn., 1866, 492, 505, 509 :—printing ink, 311.
Blacker, Lt.-Col. Valentine (1778–1826), Mad. Cav. [III, 424–5] SG, 1823–6, CB., *DNB.* ; *DIB.* ; xiii, 123, 139, 281, 346, 351, 356.
Blake, Benjamin (1788–1838), Ben. Inf. [III, 382], v, 81.
Blandford :—Henry Francis (1834–93), *DNB.*, DG. Metrgl. Dept., 140 n.5 :—Wm. Thos. (1832–1905), geolgt., FRS ; CIE. ; *Who Was Who*, 144.
Blaney :—Arthur B. (d. 1851), 269 5, 433, 439 :—Chas. A., his bro., 272 n.4 ; both civ. asst. Rev. [IV, 399].
Blanks, or gaps in maps, xiii, 23, 176, 180, 190, 193, 213, 274, 283, 308, 314 ; v. Topo. Svys., Lack of
Bleeding, surgical, 458, 460.
Blewitt, Francis Colwell (b. 1827/8), civ. asst. Trig., 21 n.2, 26 n.4 35 n.2, 36 n.4, 200–2, 241, 259, 418, 422–3, 465, 474.
Blister, therapeutic, 456, 460.
Blue colour, cobalt, indigo, 333–4 :—Lights, 24–5, 42, 103–4, 118.
Blyth :—Daniel Thos. (1820–57), 260, 433, 435, 438, 483 n.1:—Geo. Henry (b. 1829), his bro., 270–1, 435, 439 :—J., 439 :—Wm. Edw. (b. 1818, eld. bro., 270 n.5, 302, 435, 439 ; all civ. assts. Rev, [IV, 397].
Board of :—REV. :—Agra, 349 :—Allbd., 295–6, 312–3, 349 :—LP., Ft. Wm., 6, 164, 241–7, 256, 303–4, 309, 336, 349–51, 396, 462, 529, 536 :—Premises, 70, 164 :—Madras, 279 ; v. Marine ; Military.
Boatmen, 44, 141.
Boats :—Coastal, 59, 73 :—country, 16, 24, 463 :—ferry, 49, 108, 174 :—Govt. *dāk*, 463 :—Kashmiri, 141 :—Indus, x, 43, 415, 532, 540 :—River traffic, 49, 57, 185, 231, 254, 362, 370, 372, 477–8, 483–4, 525–6, 541 :—sinking, 372, 520 :—tracking or hauling, 372 n.3 ; v. Ganges.
Bogle, Geo. (1746–81), BCS. [I ; 314], 512.
Bogra, Bengal :—Rev. Svy., 241, 245, 253 :—Town Svy., 245 ; pls. 1, 4, 16, 28.
Boileau, Alex. Henry Edmundstone (1807–62), Ben. Engrs. [IV, 421–2], 25, 162, 164, 190, 374, 462 :—John Theophilus (1805–66, Ben. Engrs. [IV, 422–3], 144, 162, 520 :—John Peter (1790/1–1818), Ben. Inf. [III, 426], 252.
Boiling water :—for Health, 456, 459–60, 466 ; v. Heights ; Thermometers.
Bolst :—Geo. Chapman, office asst. Rev., 439 :—Herbert James (c. 1837–77), civ. asst. Topo. 234–6, 425, 430 :—Wm. Chapman (1825–53), soo. dmn., 318, 359.
Bolton, W. B. civ. asst. Rev., 278 n.4, 440.
Bombay, 159, 371 :—Coast. 35 :—DSG. xiii :—Engrg. Instn., 192 :—Estbt., 530 :—*Geogl. Soc.*, 139 :—Govr., 275 :—Govt., xiv, 7, 8, 55, 58, 275, 518 :—Island, 449, 511 :—Longl. Ser. GTS., 1, 54–5, 66–7, 72 :—Maps, 191, 310, 319 :—Presdcy., xv, 192 :—Rev. :—Dept., 530 ; Svy. xv 275–6, 279, 292, 396, 398, 488, 500, 510–1 :—Rlwy. 375 :—SG. 1796 [I ; 265], xiii :—Sea-level, 75 :—Topo. Svy., 1912–0, 282, 449–50 :—Trgn., 1, 3, 38, 50–1, 54–61, 101, 103, 118, 128, 191–2, 366, 391–3, 460, 518–9, 521, 523–4, 530 :—Trig. Party, xiv, 38, 54–5, 61–2, 72, 101, 122, 148, 155–7, 221, 338, 361, 391–2, 402, 406, 413, 500 :—Troops, 215 ; v. Allces ; Rev. Survrs. ; GTS. Offrs., Mint.
Bomford, Brig. Guy (b. 1899), RE., 1917 ; S of I., 1921–47, 93.
Books, scientific, 78, 143–5.
Booksellers, 306, 323 ; v. Thacker & Co.
Boots & Shoes, 466.
Borax, 501, 505.
Botanical Gdns., Sibpur, Calcutta, 183, 536 :—Ootacamund, 543 :—Saharanpur, vii, xxvii.
Botanist, vi, x, 187, 536.
Botany, v, 143, 431, 532.
Boulderson, Henry Smith (1800–77), BCS., 1817 [IV, 160] ; Comnr. Rev., Meerut, 1857, 525.
Bounaaries :—broken & scattered, 293, 300, 314 :—Changes, 313–4 :—Demarcation, 8, 185, 189, 242–5, 247–8, 251–2, 254, 259–60, 263, 265, 272, 276–6, 278, 293, 299–301 :—Estates & *zamindaries*, 264, 313–6, 218, 244, 251, 259, 299 :—Faulty, 304 :—Fiscal, 281, 284–5 :—Mapping and colouring of, 307, 311, 313 :—*parganas* and *tehsil*, 211, 243, 257, 277, 295, 298 :—Presdcy, 527, :—Provincial, 476 :—Indian States, xiii, 7, 189, 202, 475, 478, 527 :—Settmt. of, 6, 8, 188, 212, 241–2, 247, 293–4, 299, 304, 398, 501 :—Villages 6, 7, 188–9, 244, 246–8, 251, 253, 255, 258–61, 263, 272, 274, 277, 280, 293–4, 299, 304, 306, 313, 321, 324 ; v. Dist.
Boundaries, Local :—Assam-Bhutān, 512 :—Bengal & NWP., 184, 247–8, 250, 255–7, 259–60 :—Bombay, 275–6 :—British, 119, 183, 186, 190, 200, 210, 217, 307–8, 317, 508 :—Calcutta, 182, 294, 322, 474, 508 :—Delhi Territory, 258, 264 :—Hazāra, 208 :—Jammu, 119, 157, 210, 231 :—Kashmir Maharāja's, 237, 239, 506–7 :—Nepāl, 185, 252, 264, 488 :—NWF., 216, 218–9 :—Oudh-Rohilkhand, 509 :—Punjab, 211–3, 270–1, 285, 524 :—RĀjputāna, 190–1 :—Sind, 45, 193 :—Tenasserim-Siam, 490 ; v. Sundarbans.
Boundary :—Comn., 252, 264, 490 :—Comnrs., 185–7, 255, 264, 277, 310, 488, 524, 527, 544 :—Comnr. LP., 241, 243–4, 255–7, 397, 499, 529, 539 :—Disputes, 170–1, 189, 191, 212, 244–6, 251, 254, 259–60, 267, 272, 294, 301, 398, 526–7 :—Marks, 279–80, 293, 299, 304, 451 :—*Mūls*, or diagrams, 247–8, 293, 300 v. Mists. :—Rev. Svys., 242, 353, 358 :—Svys., 188, 193, 282, 288, 304, 476, 544 ; v. Pillars.
Bowel trouble, 458, 461, 465.
Bradley, Chas. (1805/6–60) [IV, 397], 255 n.6, and his son W. E. (d. 1863), both civ. asst. Rev., 440.
Brady, Peter Henry Wm. (b. 1843), civ. asst. Rev., 433, 440.
Brāhmans, 59, 222, 472, 475, 521.
Brahmaputra R., 29–31, 105, 253, 369, 477 :—Valley, 468 :—Merdl. Ser. GTS., 11, 537.
Brain disease, 212, 459–60.
Braithwaite, Chas. Wm. (1842–74), civ. asst. Trig., 418, 425.
Brāma, or Brima, Pk., Range, Glacier, Kishtwar divide, Chamba, 87, 230 n.3, 236, 239, 316, 513 ; pl. 13.
Brandy, 183, 411, 536.
Brass :—Foundry, Calcutta, 442 :—Inst. fittings, 77, 151, 160, 299 :—metal, 158.
Breakfast, 78, 458–9.
Brennan, P. M., civ. asst. Rev., 267 n.6, 440.
Breum, Christian (b. 1814/6), dmn., 354, 359.
Breweries, Murree, Solon, 419, 431.
Brick :—layers, 107–8, 110 :—makers, 18, 51, 107–8, 110, 112.
Bricks :—burnt, 18, 20, 24, 52, 106–7, 174 :—Mud, or sun-dried, 15–7, 23, 30, 39, 51, 105, 111–2 :—cost, 24 :—lost, 110.
Bridges, John, senr. (1808/9–51) and his son of same name, both civ. asst. Rev., 433, 438, 440.
Bridges, 25, 203–4, 253, 337 :—rope or suspension, 204, 224, 514 n.1 ; v. Attock.
Bridle path, 137, 224, 514.
Brigadier General, 484, 493.
British :—Admin., 4, 192, 209, 267, 292, 494 :—Association, Science, 72, 516, 541 :—Annexation, or Cession, xi, 248, 263 n.5, 264, 265 n.8, 267–8, 271, 405, 507 :—Crown, 483 :—Districts, 4, 7, 179, 189, 210, 218, 308, 324, 470, 476–8, 529 :—Influence, 480 :—Mil. Officers, 57, 191, 480, 484 :—Mll. Opns, 1857–9, 482 :—Officials, 220, 400, 507–8 :—Possessions in India, 123, 216–7, 269, 308, 478, 501 :—Expansion, xiii, 7, 81, 178, 194, 209, 342 :—Troops, 5, 130, 194, 331, 469, 474–5, 483, 485, 520, 542 ; v. H.M's. ; Boundaries.
Broach, Gujarāt, 310, 375 ; pls. 1, 28.
Bronchitis, 422.
Brooke, Gen. John Cheap (1818–99) ; Ben Inf., DIB. 191.
Broome, Arthur (1810–71), Ben. Art. [IV, 423], 200.
Brown :—IN., sketches in Burma, 196 :—Wm. (1795–1845), Ben. Inf. [III, 427], 259, 263–4, 268, 270, 297, 346, 435, 538 n.5.
Browne :—Birnie (1796–1855), Ben. Art. [III, 427], 258–261, 543 :—Gen. Sir Samuel (1824–1901), Ben. Inf., VC., KCSI., GCB. ; *DIB.* ; *Who was Who* ; 509.
Brush :—Camel's Hair, 298 :—shading, 171, 229, 318, 320, 424, 428 :—wood, 107–8, 252, 260.
Buddhist antiquities, 141 :—Religion, 528.
Budget Estimate, 166, 347, 376.
Budhon merdl. ser., GTS., 1, 14, 16, 67, 107, 125, 295, 305, 414, 523 ; pls. 3, 4.
Buffaloes, 256, 467, 504.
Building materials, 2, 51, 99, 108.
Buildings :—masonry, or brick, 51–2, 120, 141, 249, 253, 471 :—as trig. stns., 23–4, 50 n.2, 53, 61 :—obstacles to svy., 61, 103, 105 :—residences, 368.
Buist, Dr. Geo. (1805–60), Ed. *Bo. Times*, 1848–57 ; LLD., 69–70, 72, 139.
Bukhāra, Turkistān, x ; 146, 316.
Bullock, Brig. Humphry (1885–1960), IA., CIE., OBE. ; v, xxv, 501 n.1.
Bullocks, draught & pack, 58, 341, 371, 373, 463, 466, 542.
Bundelkhand, CI. ; 188–9, 403 :—Mil. Opns., 504 :—Rev. Svy., 6, 262, 267–8, 364, 436, 451, 494, 498, 504, 528, 538 ; pls. 1, 5, 16, 28.
Bungalows, 33, 138, 479, 527 :—Travellers, or *dāk*, 542.
Burdwān Dist., Bengal 255, 324 :—Rev. Svy., 6, 243, 250–1, 255, 434, 525 ; pls. 1, 3, 16, 28.
Burgoyne, FM. Sir John Fox (1781–1871), Bart., RE., GOB., Conolly (14/288), *DNB.* ; 139 n.4.
Burial Grounds, 112, 351 ; v. Cemetery.
Burma, 544 :—Civ. Comn., 505:—Maps, ix, 194–9, 510 :—PWD., 497:—Svy. :—Rev., from 1870, 436, 441–3, 536 :—Topo., 428, 435–6, 536 :—Trgn., 5, 195, 198, 492, 510 :—Telegraphs, 141 :—UPPER, 194 :—Routes, vii ; v. Pegu.
Burmese :—Survrs., 5, 196–8, 425, 447 :—War :—1824–6, 194, 494 :—1852–4, 1, 5, 194, 488, 491, 498, 523, 538, 542–3.
Burning :—Jungle, 49, 252, 261–2, 461–2 :—Records, 305 :—villages & houses, 219, 484 ; v. Fire.
Burrard, Col. Sir Sidney Gerald (1860–1943), Bart., RE., SG. 1911–9 ; KCSI., 1914 FRS., 1904 FRAS. ; FRGS., Victoria Medal, 1913 ; Obit *GJ.*, 101, 1943 (277–9), 80, 86 n.5, 89, 91, 93, 95–6, 137, 284 n.3, 500, 533.
Burrard & Hayden ; *Geography & Geology, Himalaya... & Tibet* [IV, xvi] ; xxv, 92.
Burrowes, J. J., civ. asst. Rev., 69 n.5, 433, 409 n.6.
Burt :—Chas. Henry (b. 1833), 35 n.2, 44–5, 53 n.4, 110, 200 n.2, 418, 422, 471 :—Joseph Thos. (1838/9–63), 53 n.4, 344, 404–6, 418 ; both civ. asst. Trig. and pr. bros.
Butler :—John, father & son, both Assam Pol. ; senr. (1809–74), Ben. Inf., 183–4 :—junr. (1842/3–76), d. of wounds, Nāga Hills, *GR. Topo., 1875–6* (57–8) :—Lt.-Col. Patrick E. Butler, (b. 1880), DSO., R Irish Regt., son of Gen. Sir Wm. Butler, (1838–1910), GCB., & Lady Butler, the artist, 490 n.2.
Butterworth [IV, 386], civ. Rev. Survr., 188.
Buttress, Geo. Robt. (b. 1840) & Wm. Samuel (b. 1844), bros., both civ. asst., Rev., 275 n.2, 440.
Buxton, Bentley (1796–1825), Ben. Engrs. (III, 432), Conolly, (86/109) 22–3.

Cāchār, NEF., xii, lx, 29, 33, 484, 512, 536 ; pls. 1, 16, 28.

Cadastral svy., xv, 247, 435, 499, 505, 519.
Cadell, Sir Patrick Robt. (1871–1960); BoCS. xvi.
Caird, Miss, 528.
Cairn of Stones, 27, 47, 188, 228, 529.
Calculus, mathl., 518.
Calcutta:—*Review*, 519, 522:—*Gazette*, 357, 512.
Calcutta:—Allces., 353:—Business Firms, 437, 439:—Cathedral, 525:—Circular Road, 181, 249:—Climate, 346, 458:—East Longl. Ser., 538:—Education, 404, 412, 421–2, 436:—Expenses, 536:—Heights, 66, 70:—High Court, 182, 521:—Hindu Coll., 521:—Leave to, 412:—Longl. Ser., GTS., 1–2, 11, 20–2, 24, 35, 37, 66–7, 108, 127, 128–9, 132, 149, 173, 184, 188, 278, 309, 414, 458, 510, 538:—Maps, 181–3, 250, 311, 314, 323–4, 531, 537:—Maratha Ditch, 182:—Merdl. Ser., GTS., 8, 11, 14–6, 19, 21, 24, 29, 66, 71, 75, 101, 106–8, 126, 128, 131, 148, 165, 250, 296, 361, 368, 402, 414–6, 519–20:—Museum, 526–7:—Presdcy. Town, 363, SVY., 70, 181–3, 249–50, 531:—Suburbs, vi, 6, 181–3, 241, 248–50, 467, 477:—Streets, 181, 250:—Trgn., 108:—Univ., 503; *v.* Boundaries; Comnr.; Comp. Off.; Levels.; Municipality Obsy.; Population; SGO.
Calomel, 457, 459–60.
Cambay, Gujarāt, 57, 73–4, 159, 324:—Gulf, 57–8, 67, 73–4, 118, 159; pls. 1, 3, 28, 523.
Cambridge Univ., 361, 417, 502, 539, 540 n.6.
Camels, 39–40, 44–5, 66, 224, 278, 341, 371–3, 406, 438, 459, 490, 516.
Camera:—obscuras., 82:—photo., 141–2, 331, 517.
Cameron, Hugh (d. 1769), Bo. Art. [1: 324], xiii.
Camp:—ch. of 436, 438, 458, 500:—Equipment, 362, 406, 501:—Survr's residence, 203, 406, 458:—Life, 449, 459–60.
Campbell:—Dr. Archibald (1805–84), Ben. Med., 1827–62; Pol. Supt., Darjeeling, 1840–62; Crawford's *Roll*, B. 1079; 83 n.7, 186, 473, 478:—C.B. or Chas. Wm. (b. 1831), 275 n.2, 436, 440 and James (b. 1828), 433, 436, 440; both civ. assts. Rev.:—FM. Sir Colin (1792–1863), C in C., India, 1857–60: KCB. 1849; *DNB.*; *DIB.*; 499:—Wm. Maxwell (1839–1912); Bo. Engrs., Conolly (109/188); GTS., 1863–84, 152.
Camping ground, 187, 466.
Canal:—Bench-marks, 68:—Depts.; KWP., 543:—Punjab, 68, n.5, 75, 77–9, 159, 272 n.4, 387:—Engrs., & Survrs., 50, 67–8, 192, 260, 263:—Levels, 70, 282.
Canals:—25, 79, 103, 111, 120, 258, 508, 533:—Calcutta, 70:—Delhi 264, 512, 544:—Bari *doāb*, Punjab, 68 n.5, 210 n.1, 263, 430, 490, 500, 513:—Orissa, 468:—Sind, 78–9, 192–3, 269, 276–7, 371, 443:—Svy. of, 210 n.1, 528, 538, 543; *v.* Ganges.
Candles, 79, 334, 344.
Canning, Chas. John, Lord (1812–62), GG., 1856–62, 517.
Cantonment:—Mgte. 500.
Cantonments, 19, 26, 38, 176 252, 365, 370, 378, 392, 457, 463, 471, 478:—connected by GTS., 36, 295; *v.*, Cuttack.
Cape:—Comorin, xiii, 66:—of GOOD HOPE:—186, 379, 397, 520, 529, 531, 538:—sea-route, 182, 326:—Obsy., 152, 533:—Negrais, 198:—TOWN, 523, 538; *v.* Gill.
Captain:—Gurkha, 543:—Mil. Rank, 537.
Carpenters, 24, 39, 77, 106, 108, 260, 328.
Carriage, or cart, by *dāk*, 219, 372, 499, 500.
Carriers or bearers; *v.* Porters.
Carter:—John (d. 1878), clock-maker, of Cornhill, London, Lord Mayor of London, 415:—Thos. Tupper (1838–1900), Ben. Engrs.; GTS., added name Campbell, 1893; Conolly (93/335); Sandes, II (201) *REJ.*, 1900 (106–7); 186, 506.
Cartographers, or map-makers, 89, 540.
Carts, bullock, 40, 43–4, 57–8, 158, 371, 373, 463, 488, 500, 509, 542.
Carty, Chas. Jordan (b. 1830), civ. asst. Trig., 37 n.3, 43–4, 47 n.2, 75, 77, 79–80, 159, 209, 408, 418.
Cary, Wm. (1759), inst.-maker [IV, 479]. *DNB.*; 148, 150, 152, 156, 158, 299.
Cash:—cost, 373, 377:—draft, 374, 485:—payment, 236:—safety, 378:—supply, 363, 377, 438, 483, 485, 515.
Casualties:—by accident, 483:—natural, 177, 226, 228, 350, 382, 386, 397, 433, 458, 475.
Catalogue of Maps, etc. (*IO Cat.*) XXVI, 824.
Cattle:—39–40, 57, 108, 192, 207, 254, 499:—for transport, 347, 362, 371:—theft, 40; *v.* bullocks.
Caucasus, or Himālaya [1: 67–8], 87.
Cautley, Sir Proby Thos. (1802–71); Ben. Art. [IV, 479]; Supt. Canals; *DNB.*; *DIB.*; 68, 533.
Cavalry:—Bengal, 380, 523:—escort, 376:—irregular, 492:—British Dragoons, 437–443:—Offrs., 10, 177, 379–80, 384, 390, 492, 532.
Cawnpore, 118, 262, 267, 337, 485, 492, 499, 543:—Cants., 267:—City svy., 262, 267, 337, 371:—Rev. Svy., 313, 529:—Dist., 264 n.3; pls. 1, 3, 4, 16, 28.
Ceded Dists., Madras [II, 152, 181; III, pl. 1], v, 8, 279.
Cemetery, Christian, 477, 491:—Dehra Dūn, 505; *v.* Masrl.; Simla.
Censure, or reprimand, 390–5, 427, 508, 512, 520.
Centering, of insts., marks, & signals, 41, 105, 107–10, 112–14, 286; *v.*
Central:—ASIA, 146, 239, 515, 528, 544:—Maps, *540*, 544:—INDIA 146:—Maps, 4, 188–90, 315–6, 324, 452, 489:—Topo. Svy., 363, 388–9, 424, 447, 510, 525:—Trgn., 2, 105, 375:—PROVS. (CP.), 178, 188, 416–7, 425, 428, 482–3, 486, 496:—Maps, 349, 387:—Rev. Svy., 6, 267–8, 365, 396, 434, 436, 499, 528, 540; *v.* Disturbances.
Cession, or Annexation; *v.* British.
Ceylon, 146, 492.
Chach, plain of, nr. Attock, 36–7, 42–3, 209, 371; pl. 9; *v.* Base-lines.
chaddar, or village plan; 303, 305–6.
Chain:—*jarib*, or iron, 100 ft., 77, 165, 299, 302, 863:—Gunter's, of 66 ft., 165, 209, 249, 304:—men, 455:—svy., 8, 185, 195, 260, 282:—unit of length, 78:—or SERIES of Triangles, 84, 101, 118, 127–8, 130–1, 184, 286–7, 540; *v.* Longl.; Merdl.; Traverse.
Chalk, for lithography, 219, 330–1.
Chalks, river surv., Bengal, 463.
Challis, Rev. James (1803–82), BA., Camb., senr. wrangler, 1825; *DNB.*; *RAS* (*mn*), 43 (160); 502.
Chamarett, Andrew:—senr. (1793–1946), 177, 285 n.3, 290, 884, 421, 428–30, 432:—junr. (b. 1833), 178, 179 n.4, 211–2, 424, 427–8, 430, 485–6; father & son both civ. asst. Topo. [IV, 385].
Chamba, NW. Himālaya, 5, 86, 200–1, 204–6, 208, 227, 231, 239, 271 n. 316, 423, 496, 512–3:—Hills, 86, 283, 416; pls. 1, 3, 5, 6, 11, 16, 28.
Chambal R., Central India, 190, 267 n.1; pls. 1, 4, 5, 28.
Chamberlain, FM. Sir Neville Bowles (1820–1902), GCB.; GCSI.; *Ency. Brit.*; *DNB.*; *DIB.*; 217, 490, 539.
Champāran Dist., Bihār, 82–3, 543:—Maps, 313:—Rev. Svy., 6, 241, 242; pl. 16.
Chandernagore, Bengal, 247–8, 522.
Changchenmo R., E. Ladākh, 236–7, 399, 425, 489–90, 506; pl. 6.
Chandra-Bhāga R., or Upper Chenab, 201–5, 227, 229, 231, 516:—Bhāga R. 516–7; pls. 6, 11.
Chapman, Chas. (1815–82), BCS., 1833; Supt. Rev. Svy., Patna, 1850, 451–3.
chaprās or badge, 473, 479.
chaprāsi, office attendant, or *peon*, 141, 364, 374, 377–8, 454, 471–2, 476, 478–9, 483.
Charcoal, 260, 297, 466.
Charge:—of Svy. Parties:—GTS., 97, 114, 120, 126–7, 362:—mil. offrs., 361, 380, 382–3, 409, 467, 506:—by Civ. Assts., 12–3, 25–6, 30–1, 33, 336, 361, 381, 402, 407, 414–5–6–7–8, 506, 510, 517, 520:—Rev. Svys., 241, 350, 433, 455:—Mil. Offrs., 251, 254–5, 266, 269–70, 396–8, 525, 535, 538:—by civ. assts., 243–4–7, 251, 254, 279, 433–6, 505, 510, 543–4:—TOPO. SVYS.; *v.* Camp.; Mil. Offrs., 167–8, 172–3, 177–8, 385–6, 389–90, 518, 525:—Civ. Assts., 175, 426–7, 517, 519:—Allowances, 407, 429.
Charts:—Nautical, 195–6, 324; *v.* Coastal:—Trgn., 83, 87, 91–2, 98–100, 120–1, 127–9, 239, 291.
Chatelier, Joseph (d. 1852), civ. asst., Topo. [IV, 386], 168 n.2, 170, 421, 428, 430.
Chattardhar Range, NW. Himālaya, 222, 227, 230, 517; pl. 6.
Chaur Peak, Sirmūr, 11,966 ft. [III, 520; pl. 5; IV, 480], 81, 137, 202, 206–7, 505.
Cheape, Gen. Sir John (1792–1875); Ben. Engrs. [III, 432], 503; *DNB.*; *DIB.*; Conolly (86/99); 70, 194.
Check, or test on fd. svy.:—Rev. Svy., 265, 279, 300–3, 449:—Topo. Svy., 229, 290, 367, 385, 447; *v.* Inspection; *partial*.
Chemistry, 405:—Prof. of, 140.
Chenab R., Punjab, 7, 52, 75, 273–4, 296, 316, 508:—Upper, 202, 205 n.6, 222–4, 227, 230–1, 485, 512, 518; pls. 1, 3, 5, 6, 16, 28.
Chendwar merdl. ser., GTS., 2, 12–3, 15–9, 36 n.5, 85–6, 126, 128, 148, 361, 382, 498, 501, 511, 520, 541; pls. 3, 4.
Cherrapunji, Khāsi Hills, 2, 31–3, 544; pls. 1, 3, 28.
Chew, Robt. (b. 1819), civ. asst, Topo., 174, 430.
Chief:—Civ. Asst. GTS., 10, 345, 402–3, 406–8, 414–5, 510, 520, 522, 542:—ENGR.:—Bengal, 330, 339:—Bombay, 8, 191, 261, 264, 449–50, 495, 524:—before Delhi, 1857, 534:—Madras, 181, 319:—Punjab, 77, 159, 272, 512; *v.* Comnr.; Comptr.
Chiefs, rājas, & rulers, xi, 42, 55, 173–4, 188–9, 219, 200, 231, 302, 310, 471, 478–9; *v.* Gulāb Singh; Kashmir.
Chilās, Indus Kohistān, 209, 481.
Chilcott, Maj. Joseph (1807–69), Ben. Inf., Inv., from 3–10–43; *d.* Masrl., Hodson, I (339), 341 n.2.
Chillānwala, Punjab, battle of, 13–1–1849, x, 25, n.4, 490, 524.
Chilka Lake, Orissa, 28, 118, 169, 174, 526, III, pl. 1; IV, pl. 2.
Chill, Thos. Potenger (b. 1842), dmn., 359:—Wm. Richd. (b. 1809), his uncle, civ. asst. Rev., 12 n.11, 255, 433, 437–8, 440.
China, 240, 496:—Wars with England; 1842, 464, 519; 1860, 488.
Chinese:—Frontier, trans-Himālaya, 233–4, 236, 496:—People, 240:—Tartars, 236:—Tartary, 204, 237:—Territory, 203, 235–6, 426:—Paper, 329; *v. Tartars*; Tartary.
Chini, upper Sutlej, 203, 208, 430, 479, 496.
Chitrāl, KWP., 86, 886, 481, 538.
Chittagong, E. Bengal, 33, 70, 483–4:—Hill Tracts, 243, 364, 483, 485, 512:—Men, 45–4, 453–4:—Road to Akyab, 495:—Maps, 312; pls. 1, 3, 4, 16, 28.
Cholera, ix, 16, 18, 27–8, 231, 261, 453, 437, 442–3, 458, 461, 466, 482, 529.
Chomorari Lake, Morari Tso, Ladākh, 186, 234, 489, 515; pl. 6.
Chota Nāgpur, 13, 538:—Maps, 311, 315, 324:—Rev. Svy., ix, 6, 7, 184, 243–4, 273, 364–5, 435, 451, 454 n.3, 497, 535:—Topo. Svy., 175–6, 184, 308, 387, 496.
Chowringhee, Calcutta, 70, 351, 356.
Christians, and Christianity, 410–1, 490.
Christmas Day, 529.
Chronometrs, 146–7, 163, 344, 363, 495:—Rate of, 126, 147; *v.* Longitude.
Chumalhari Peak, Bhutān, 23,930 ft., 83, 85, 91–2, 417; pls. 3, 4.
Chunār, Mirzāpur, 12, 140, 361, 509, 518; pls. 1, 4, 28; *v.* Arsenal.
Cigars, 411, 504.
Circārs, or dists., of Hyderābād, 177–8.
Circle:—Horizontal, or azimuth, 84, 150–4, 157 n.6:—Vertical, 84, 131, 151–3, 157:—& dot. svy. mark, 112.
Circuits:—levelling, 62–3, 76, 78:—Boundary Traverses, 251, 264, 293, 297, 497:—Closing, 535:—Main, 216, 243, 251, 278, 294, 298:—Plans, 306, 313:—492:—Village, 196, 274, 293, 298, 301; *v.* Traverse.
cis-Sutlej:—States, Punjab, 7, 200, 269, 316, 318, 509:—Supt., 480:—Territory; Rev. Svy., 7, 50, 266, 268–70, 273, 294, 316, 364, 396, 435–7, 492, 494, 530, 539.; pl. 16 n.1.
Cities:—connected to GTS.:—Plans & Svys.; *v.* Towns.
Civil:—Assts.:—Bo. Rev. Svy., 402:—GTS., 336, 342, 345, 361 n.1, 402–20:—Princpl., 405, 407:—Sub-Assts.:—Authorities, 4, 170, 416, 479, 516:—Officials, 14, 46, 31–2, 175, 178, 218, 219, 285, 314, 316, 368, 426, 476–80, 482, 484, 517, 523; *v.* Dist.; Local:—Rev. Offrs. 247, 266, 269, 277, 299–300:—Bo. Rev., 398:—Service uncov., 173, 405, 414:—Comn., Burma, 197:—Punjab, 435, 439; *v.* Engrs.; Supts.; Surgeons.
Clarke, Col. Alex. Ross (1828–1914), RE. [II, 262]; CB., FRS., 1862; Conolly (31/802); *RS Proys.*, 90 (xvi–xviii), 125, 152, 540:—

Lawrence Henry (b. 1834), civ. asst. Trig., 51 n.3, 87, 90 n.6, 234–7, 418, 425, 506.
Clarkson, Richd. (b. 1817/8); civ. asst., Trig. [IV, 480]:—Maluncha Ser., 14, 22 n.2, 23–9, 371, 308, 361, 522:—E. Coast Ser., 62, 65, 103–4, 117–8, 153, 155, 173, 413, 463, 465, 490, 522, 583:—promotion, 402–3, 408–9, 415–6:—Domestic, 418.
Classification of land, 8, 242, 272, 280.
Claudius, Thos. (1816–63), civ. asst. Topo. [IV, 480], 171, 172 n.5, 176, 428, 431, 464.
Clerical est., 166, 336, 349, 352–3, 359.
Clerke, Capt. Augustus Jonathan (d. 1858), RE., Conolly, (31/799), 493 n.5.
Climate:—Bengal, 452, 535:—Dry, 452:—Healthy, 180, 220, 365–6, 368:—Humid, 65, 107, 452, 454:—Injurious to records, 326:—Local, 26, 31, 98, 378, 396, 448:—Pestilential, 27, 29, 173, 278, 366–7, 457, 462–3, 467, 490, 519, 527:—Unhealthy, 116, 168–9, 177, 196, 213, 305, 373, 375, 386, 411, 429, 445, 438, 532; v. Assam; Calcutta; Misri.; Sind.
Clinometer, xv, 4.
Clive, Robt. Lord (1724–84); Govr. Bengal 1765–7; *DNB.*; *DIB.*, xiii.
Clocks:—Basevi Memorial, 491:—Tidal, 74.
Clothing:—32, 223, 261, 279, 464, 466, 474:—washing, 448:—Mil. Dept., 501.
Clouds, 15, 25, 51, 58–9, 83–4, 88, 130, 132, 207, 221, 223–4, 229, 231, 493, 514, 541; v. Fog; Mist.
Clubs, London:—Athenaeum, vii, 324, 541–2:—Oriental, 502 n.7, v. East India.
Coal, 142–3, 145, 324, 513, 523:—beds, 142, 526:—mines, 15, 23.
Coast:—Ganjam, 462:—Indian 62, 69–70, 307:—Orissa, 22–3, 27–8, 173–4, 467, 504, 526:—west, 567, 490; v. Coromandel; Cutch.
Coastal Charts:—Arakan, 195:—Orissa, 28, 173–4, 176.
Coast-line, svy. vi, xiii, 173–4:—Mar. Svys., vi, ix.
Cocos Is., N. of Andamans, 416, 519.
Coffee:—to drink, 459:—plantations, 280.
Coimbatore, S. India, 179–80, 542:—Maps, 180:—Rev. Svy., 280, 503; pl. 28.
Colāba, Bombay, 73:—Obsy., 70, 139:—Rev Svy., 498 n.5; pl. 1; v. Astr.
Colby, M. Gen. Thos. Fredk. (1784–1852), RE. [IV, 480]; DG. OS 1820–47, FRS., *DNB.*; Conolly (14/314): 204, 44, 158, 339, 523.
Cold, 223, 510:—Catarrh, 543:—Weather, 5, 118; 225, 233, 365, 455, 464, 505, 512, 528–9, 543:—or Winter Season, 36, 389, 423, 429, 488, 499.
Cole, Wm. Hammond (1837–1917), MA., Camb.; mathn.; arrd. India, 1862:—GTS., 1867–92; Comp. Office, DDn.; FRAS.; 502.
Colebrooke:—Henry Thos. (1765–1837), BCS. [II, 386], FRS.; *DNB.*; *DIB.*; v, 65, 81:—Lt.-Col. Robt. Hyde (1762/3–1808), Ben. Inf. [II, 386–91], v, 81, 494:—Robt. Hyde, junr. (1827–49), his g. son, 494.
Collections, scientific, 142–3, 146, 526–7, 536.
Collectors:—of Dists.:—Bengal, 242, 247, 299, 476, 543:—Bombay, 191:—Asst., 398, 530:—Madras, 27, 464:—NWP., 275, 305, 313, 434, 442:—Sind, 277:—Revenue, 260–1; v. Deputy.
Colleges, Indian, 344:—Military, 508; v. Addiscombe; Sandhurst.
Colour:—for Maps, by hand, 194, 306, 324–5:—Printing, v. Litho.; Postage Stamps.
Colquhoun, James Andrew Sutherland (b. 1839); Ben. Art. 1858–95; 192.
Commander:—Army, in Burma, 384:—in-Chief:—India, 189, 274, 535.
Commerce, 185, 239.
Commissariat:—Dept., 371–4, 436, 483–4:—organization, 236, 466.
Commissary, 372, 374:—Gen., 339:—Assts., 465–6, 499, 501.
Commissioner:—Asst., 197, 242, 285, 477, 491, 515 n.1:—Chief:—Assam, 461, 476:—Oudh, 263:—Pegu, 195–7, 384, 498:—Punjab, 211, 221, 228, 269 n.3, 272 n.3, 285, 376, 476, 485, 539; v. Deputy.
Commissioners:—Bengal, 242, 251, 254, 257, 294, 322, 350, 476, 529:—Cuttack & Sambalpur, 173, 176, 377, 427, 463, 477, 483:—Calcutta Improvement, 181–2:—NWP., 305:—Punjab, 200, 204, 269, 456, 471, 477, 480, 517, 524:—Rev. Svy. & Settlmt., Bombay, 488, 498:—Sind, 193, 277–8:—Tenasserim, 425; v. Revenue.
Committee:—Coal & Mineral Resources, 142:—Deptl., 95, 502:—Pegu Svy., 498:—Health, 465–6:—Svy., of 1905, xv.
Commons, House of, London, 307, 345 n.6.
Commonwealth Relations Office, London, (CRO), 324.
Communications, 204, 483.
Compass:—Bearings, 104, 216:—pocket, 187, 448, 495:—with Plane-table, 288:—Prismatic, 185, 208, 215, 255, 260, 277, 540:—protracting, Bengall, 299:—Schmalcalder, 187:—Svy. by, 5, 187, 190, 195, 278, 302.
Compensation:—Bars, Colby, 20, 97, 158:—Payment:—by survrs., 24, 475, 477–8:—to Survrs., 35, 413, 420, 507:—of Errors, 130.
Compilation:—Geographical, 113, 120, 239, 317, 353; v. Map.
Compilers, dmn., 327, 342, 353–4.
Compounder, medical, 457.
Computations:—attested & compared, 122, 354:—GTS.:—fd. units, xiv, 10, 19, 91, 120, 122, 126–7, 225, 344, 361, 369–70, 380–3, 409, 513, 519, 521, 525, 530:—*Geodetic*, xiv 10, 101, 121–9, 341–4, 365, 410, 417, 501, 516, 520–2, 523, 540:—Rev. Svy. traverses, 196–7, 235, 244, 265, 278, 293, 304–5, 350, 438, 501–2, 521:—Topo. Svys., 168–9, 172, 210, 213–4, 226, 228, 282, 285–6, 290, 292, 368, 385:—Snow peak obsns.; t-page, 17, 65, 82, 85, 89–95, 128, 343, 417, 423, 424–5, 446, 448, 501–2, 519; v. Gr. Arc.
Computer; Chief, 10, 64, 67, 521–2:—with fd. Office, 122, 308, 341, 354:—at Calcutta, 90–3, 121–8, 135, 140, 163, 284, 323, 341, 343–4, 352, 354–6, 404, 446, 523, 530, 537:—Depy., 128, 356, 402, 414.
Computers; GTS. staff, 123, 127–8, 140, 211, 341, 344, 351, 354–6, 360, 372, 378, 427, 521:—Offrs. & Assts., 90, 366, 402, 415, 417, 501:—Rev. Svy., 280, 436, 451:—Training of, 344.
Computing Office:—Calcutta, xiv, 121–4, 127–8, 139, 338, 341, 344, 351–2, 446, 521–2, 536:—DDn., 90–1, 93, 128, 225, 341, 343–4, 417, 501–3, 521–2.
Conference, Rev. Svy.:—Allahābād, 1833, 398:—Bombay, 1847, 276, 298, 305–6.
Congregated Maps, Rev. Svy.:—Fields, 293:—Villages, 243, 273, 298, 305–6.
Conner, Peter Eyre (1789–1821); Mad. Inf. [III, 433], 280, 421.
Conservancy Dept., Calcutta, 183, 250.
Constitution, physical, 368, 424–5.
Consumption, or tuberculosis, 422.
Contingent:—Advances, 363:—Allces., 278, 398:—Bills, 138, 218, 290, 320, 323, 346, 350, 354, 361–3, 406, 430, 478:—Charges, 164, 362, 365:—Expenses, 149, 165–6, 278:—SG.'s counter-signature, 342, 346, 362–3.
Contours, 4, 67–8, 290:—by Rev. Survrs., 119, 262.
Contract:—for *khasrah* svy., 263, 300, 451:—Svy. & contgt. Allces., 346, 361, 375, 393:—for tower building, 110.
Control, Geogl. v. GTS.; Prof.; Rev. Svys.
Controller of Rev. Svys., Bengal, 242, 247.
Conventional signs, 291, 321.
Conyngham, Col. Sir Gerald Ponsonby Lenox-(1866–1956), STS., 1912–21; portrait, *Geod. Rep.*, *I*, 1922–5; Kt., 1919, FRS., 1918; *Nature*, 198, Dec. 1956 (1211–2); Conolly (61/1802); 533–4.
Cooch Behār, N. Bengal, 29–31, 243, 246, 369, 435, 476, 519; pls. 1, 3, 16, 28.
Cooke, Thos. (1807–68), inst.-maker [IV, 480], FRAS., *Ency Brit.*, 358.
Cooking of Food, 459, 463, 466, 474:—Cook, 367, 411.
Coolies; 30, 32, 39, 172, 213, 261, 362, 377, 406, 455, 468, 476–7, 480, v. labourers.
Coombe, Dr. Andrew, (1797–1847) auth. of *Physiology of Digestion*; pub. Edinburgh, 10 edns. 1836–60, 459.
Coonoor, Nilgiri Hills, 542.
Cooper, A., civ. Asst. Topo. 198–9, 425, 431, 440.
Co-operation:—DSG. & Rev. Bd., 351:—GTS. & Rev. Svy., 272, 296:—Rev. Survrs. & Rev. Staff, 263, 271, 293, 301.
Co-ordinates Rectangular, 186, 295, 297–8.; v. Geogl. positions.
Coorg, S. India, Atlas Sheet No. 43; vii, 311; pls. 19, 28.
Copper, 142, 144:—Plates, engraving, 181, 320, 322, 328, 334–5, 540:—Sulphate, 288 n.5.
Copyright in Maps, 323–4, 326.
Corbett, Sir *Geoffrey Latham* (1881–1937), ICS., 1904–34, KBE.; CIE.; Joint Founder of Himālayan Club, 1927, 188.
Corfield, Wilmot, (1859–1919) philatelist, FR Ph S., 1899, 335.
Cornelius, John (1802/3–79), dmn. [IV, 481], 341, 343, 359:—Walter John, his son (1849–1931), civ. asst. Trig., 343, 359.
Coromandel Coast, vi, 45, 285.
Correspondence, 121, 166, 257, 532:—disrespecful, 393–5, 412, 496–7, 497–8, 530–1:—Fd. Office, 343:—half-margin, 344:—submitted to Govt., 395, 497–8:—SG.'s, xii, 341, 344–6, 362, 367, 392–5:—Staff, 341:—SGO., Calcutta, 352–3.
Cosimbāzār, Bengal, 477:—River, 372 n.2.
Costs:—Rev. Svy., 294:—Topo. Svy., 189, 198:—Rates, 188, 197–8, 206, 214, 243, 247, 250–1, 278, 280, 282, 289, 294, 366.
Council of India, London, 511.
Cowie, Herbert McCally (1873–1925), RE., s. of I. 1898–1925, *Geod. Rep.* III (1), 96, 137.
Cow:—dung, fuel, 234, 236:—herds, 470:—milch., 364.
Crane, hoisting, 53, 106.
Crawford, Chas. (1760–1836), Ben. Inf. [II, 392–3]; SG., Bengal 1813–5; 81–2, 91–2, 318:—James Henry Graham (1812–60), Bo. Engrs.; Conolly (105/87); SE. Rlwys., 1855, *IO Cat.* (154); 193 n.4, 495.
Creeks, 2, 25, 29, 174, 197, 519:—tidal, 25, 29, 104, 174, 255, 283, 468, 526:—Irrawaddy Delta, 196.
Cribble, Sgt. H.J. (b. 1812–3), Ben. Eur. Art. 1838–58; from England, 24–8–38; asst. MI. Maker, 148, 154, 164–5, 358, 360.
Crommelin, James Arden (1801–93); Ben. Engrs. [III, 435]; Conolly (86–123); 186, 497.
Cross Staff, rev. svy., 268, 276, 297.
Crossley, Wm., Sgt. RE., 331 n.6.
Crosthwait, Herbert Leland (1887–1939), RE., STS., 1921–3; CIE.; Conolly (69/2030); *Geod. Rep.*, II(1); 137.
Crow, Michael, senr. (d. 1846/7), Dep. Collr. Bengal [IV, 192], 181, 241, 249–50:—junr., his son, 181, 249.
Cuddapah, S. India, 280, 494–5.; pl. 28.
Cultivated land, 170, 173, 179, 188, 214, 218, 243, 266, 279, 293–4, 301.
Cultivation:—land culturable, 8, 265, 279–80, 301:—uncultivated, 170:—limits survd., 6, 201, 213, 218, 269, 278–9, 282:—riverain 257:—scanty, 36, 40, 244, 264, 272, 508:—spread of 258.
Cultivators, or *ryots*, 27, 272, 279, 292–3, 499.
Cunningham, Sir Alex. (1814–93), Ben. Engrs. [IV, 428]; KCIE.; *DNB.*; *DIB.*, Conolly (88/178); x, 186–7, 200, 220, 240, 518, 531, 536:—Alex. Chas. (1833–86); civ. asst. Trig. & Sco., 26 n.4, 352, 359.
Curry & Rice, xxv, 366 n.3:—Curry, 466.
Curvature of Earth, 62, 75, 102, 105.
Customs:—Tax Dept., 430, 438, 440, 442, 543:—or Habits, 40.
Cutch v:—Coast, 64, 57–60, 141, 146, 406, 470:—Coast Ser., 54, 59–60:—Gulf of, 72:—Rann of, 39–41, 58–60, 65, 98, 102, 340, 467, 518:—Trgn., 500, 518; pls. 1, 3, 5, 28.
Cuttack, Orissa:—Cantonments, 26–7, 164, 168–76, 184, 370–1, 377–8, 407, 429, 463, 465, 483, 520, 526–7, 532–3:—Collr., 174:—Dist., 22, 296, 386, 477:—Mgte., 364:—Maps, 311:—Obsy., 370:—Rāja, 174:—Recess Qrs., 178, 364, 370, 495–6:—Rev. Svy., 303, 397; pls. 1, 3, 4, 16, 28; v. Orissa:—Trib. Mahāls.
Cyclometer, 160.

Dacca, 253:—Cants., 31, 372–3, 483:—City svy., 252:—Climate, 436:—Maps, 312; pls. 1, 3, 4, 16, 28:—Recess Qrs., 29, 369, 438, 484, 496:—Rev. Svy., 6, 243, 254, 294, 434, 482, 543.
Da Costa, Joseph (b. 1814/5), civ. asst. Bo. Trig. [IV, 386], 54–5, 57–60, 74, 103, 408, 418.
daladar, 77, 158, 222 n.5, 226, 371, 454–5, 460.
daftri, office attendant, 352.
dāgh, [IV, 180 n.7] field partition, 451.

dāk, or post, 89 :—*bhangi*, or parcels post, 124, 362 :—bungalow, or rest house, 223–4, 249 :—travel by, 337, 371–2, 488, 499 :—Palanquin, 332 :—Runners, 527 ; v. Carriage.
Dalhousie :—Punjab hills, 273, 508 ; pls. 1, 28 :—Lord ; James Andrew Broun Ramsay (1812–60) ; 10th Earl, cr. Marquess 1849 ; GG. 1847–56 ; Burke (581) ; *DNB.* ; *DIB.* ; 494.
Daly, Robt. (d. 1862), civ. asst Topo., 179 n.4, 422, 428, 481.
Daman-i-koh, Bihār, [III, 137] 254–6, 306, 529.
Damargida, nr. Bidār, Hdbd. ; 66–7, 72, 124, 137 pl. 3.
Dampier, Wm. (1798–1861), BCS. [III, 142–3], 249.
Dances & Dancing girls, 141, 508.
Dandy, *dhooli*, or *shampān*, 19, 149, 371, 429–30, 438, 542 :—Alice., 430 ; v. Palanquin.
dang, or rough country, 461, 467.
Dangerfield, Fredk. (1789–1828), Bo. Inf. [II, 435–6], 196.
Dangers on svy., 215, 219, 510.
Daniell, Alex. (1812/3–55), civ. asst. Rev. [IV, 481], 181, 183 n.4, 349, 352, 359, 435, 440.
darbār, or State Council, 481, 506, 515, 543.
Dards, of Gilgit, 240.
Darjeeling, Sikkim, 4, 15, 19–20, 29–30, 65, 83, 85–6, 91, 94–5, 137, 145, 186, 336, 368–9, 393, 434, 453, 461, 489, 519–20, 529, 542 :—Civ. Supt., 186, 478 :—Recess, 29–30, 246, 519, 541 :—Rev. Svy., 83, 186, 255, 529 :—Sketch, 529 :—Tea svy., 441 :—Topo. Svy., 1882–6, 428, 432 :—SG.'s Trgn. 1847 ; 29, 65, 83, 95–6, 91–2, 118, 186, 341, 541–2 :—Waste Lands svy., 1872, 505, 336–7, 341, 510, 521, 523.
Davey :—Nicholas Thos. (b. 1823), 243, 254, 294, 364, 433 both civ. asst. Rev. :—Wm., his bro. (b. 1827/8), 440.
David, Chas. (b. 1827/8), civ. asst. Rev., 433, 440.
Davidson, Sir David (1811–1900), Bo. Inf. [IV, 429], KCB., 1897 ; 275–6, 398, 401, 435, 440, 488 :—Wm., his bro. (b. 1827–8), civ. asst. Bo. Rev., 248, 433, 440.
Davies, Sir Robt. Henry (1824–1902), BCS. ; KCSI. 1874 ; *DIB.* ; LG. Punjab, 1871–7, 302 n.3.
Davison, Lieut. Thos., asrd. India with HM. 84th Ft., pr. Capt. 7-7-45, Sind, Rev. Svy. 1843–4, 494.
Dean & Sons, & Straker, makers of printing machines, London, 329.
Deaths :—GTS. :—Mil. Offrs., 2, 10, 12, 19–20, 43, 83, 186, 336, 379–80, 383, 385, 483, 491, 493, 541 :—civ. Offrs. & Assts., 16, 228, 342–3, 414–8, 435, 446, 508, 511, 518 :—Followers, 14, 16, 17, 26, 28, 453, 456, 460–2, 463, 466, 510 :—TOPO. :—Mil. Offrs., 4, 167, 215, 385, 462, 500, 513 :—civ. assts., 170, 173, 178, 211, 422, 426, 428, 518 :—Followers, 367, 463, 489 :—REV. SVY. :—Mil Offrs., 270, 483, 492, 494, 497, 500, 504, 531, 538–9 :—civ. offrs., & assts., 6, 248, 271, 433–6, 438–9, 483, 544 :—Followers, 256, 278 :—SGO., 353–4, 458, 463 :—Domestic, 395, 495, 504, 526, 534, 536 :—Escorts, 18.
De Brett, M. Gen. Harry (b. 1834), Ben. Inf., Ens. 1853 ; with GTS. for Kashmir Svy., recess months, 1861–2 ; 506.
Debts, 412, 438, 443, 453, 489, 532.
Deccan, 2, 3, 54–5, 101, 267, 500 :—Maps, vii, 191 :—Rev. Svy., 275, 277–8, 293, 398, 488, 495, 498, 500, 521, 523 :—Topo. Svy., 7, 191, 200, 530 :—Trgn., 101.
Decimal Coinage, 527.
Deer & Antelopes, 235, 467.
Deesa, Rājputāna, 38–40, 504, 518 ; pls. 1, 3, 28.
De Filippi, Cavalier Filippi (1869–1938), anth. & mountaineer ; KCIE. ; 240, 506.
Deflection of Plumb-line, xv, 66, 88, 92–4, 98, 124, 132–7, 234, 155, 520–1, 530 ; v. Attraction.
Degree, length of, 123, 191, 208, 289 ; v. Figure of Earth.
Degree Sheets, ½-inch Maps :—NW. Himālaya, 310–1, 318–9, 342 ; pl. 6 :—of 1905, 311.
De Hone, litho-printer, 357, 360.
Dehra Dūn (DDn.), NWP., xiv, 2, 5, 19, 37, 67, 69, 133–6, 140, 150, 371, 482 :—Dist. 483 :—Dūn Valley, 207, 519 :—Fd. Party Hdqrs. 11–2, 46, 50, 122, 213, 225, 237–8, 343, 352 n.3, 368–71, 409, 488, 506, 510, 512–3, 538, 542 :—SG.'s Fd. Hdqr., 36, 42, 78, 121, 159, 213, 266, 336–8, 341, 346, 352, 380, 410, 415, 417, 521 :—Printing Off., 123, 129, 141, 331, 502 :—GTS. Hdqrs., 9, 496, 502–3 :—History, v :—Premises, 138, 341 n.2, 491 :—Residences, 341 n.2, 510 :—Maps, 510 n.3 :—Latitude, 133–6, 136 :—Topo. Svy., 538 :—Rev. Svy., 1847–8, 263 ; pls. III, 3 ; IV, 17 ; V, 3 ; v. Cemetery ; Obsy. ; Comp. ; DO. ; Supt.
De La Rue & Co., printers, London ; Thos. (1793–1866), printer from Guernsey ; 334 n.4.
Delhi, 50 :—Ancient Cities, 324 :—City Svy., 6, 265 :—Dist. Svy. & Map, 265, 324 :—King of, 264 :—Qutb Minār, 265 :—Rev. Svy., 219, 258–9, 264–5, 433, 451, 494, 508 :—Ridge, 265 :—Siege & Capture, 1857, 1, 229, 444, 482–3, 485, 493, 497, 500, 515, 528, 534, 539 :—St. James' Ch., 492, 494, 498.
De Pree, Gen. Hugo (1870–1943), RA. ; Comdt. RMA., 1926–30 ; 495–6.
Deosai Plains, Baltistān, 89, 226–7, 229, 232, 235, 286, 485, 493.
De Penning, Joshua (1784–1845), Ch. Compr. [IV, 430–1], 121, 127, 163, 323, 354, 522.
Departmental : Orders, & Circulars :—Svy., 63–5, 112, 117, 119–21, 127 :—pub. Papers & Tables, 137, 522 :—Rules & usage, 386, 530.
Deputy :—Collectors, 6, 183, 193, 242, 244, 246–8, 251, 271, 294, 299, 301, 403, 414, 443 :—Cmnrs., 47, 201, 243, 264, 269, 271, 322, 474, 480, 492 :—Mgtes., 181 :—Supt., s of l., 353, 414.
Deputy Survr. Gen. (DSG.) :—SGO. Calcutta, xiv, xv, 1, 6, 8–9, 23, 67, 69, 79, 88, 91, 136–40, 142, 151–2, 159, 162–4, 166, 169, 179, 183–4, 209, 340, 348–51, 336, 338–9, 344, 346, 358, 367, 435, 522, 536–7, 521–2, 527 :—Allces., 164, 348 :—Mil Rank, 339, 349 :—Charge of Maps, 295, 323–5, 357, 537 :—Postage stamps, 332, 334, 357, 537 :—Supt. Rev. Svys., 218, 241, 243, 245–7, 256, 264, 266, 269–70, 295, 305, 313, 334, 336, 346, 348–51, 365, 395–7, 451, 491, 499, 525, 528–9, 536–7, 539 :—ch. Topo. Parties, 143, 348–9, 477, 527 :—DSG., Topo. 428, 496, 537 :—Trig. xv, 500, 502, 539 n.1.
Deputy Survr. Gen. :—Bombay, xiii, 191 :—Madras, xiii, 177, 319, 380.
Dera Fateh Khān, NWF., 47–8, 217, 219 ; pls. 1, 5, 28.
Dera Ghazi Khān, NWF., 48–9, 77–80, 217, 219, 274, 540 ; pls. 1, 3, 5, 16, 28.
Dera Ismail Khān, NWF., 47–8, 76, 78–80, 146, 216–7, 219, 316, 451, 476 ; pls. 1, 3, 5, 16, 28.
Derajāt, NWF., 4, 47–8, 210, 216–9, 285, 475 :—Depy. Comnr., 492 :—Johnstone's Svy., 274, 317, 331, 364, 397–8, 400, 451, 508, 528 ; pl. 16.
Desert country, t-page, 406 :—Punjab & W. Rājputāna : "Great Indian Desert", 3, 7, 27, 38–41, 46, 51, 53, 98, 111, 212, 273–4, 283, 340 :—S. Rājputāna & Sind, "The Little Desert", 2, 31, 40, 97, 109, 192, 279, 379, 416, 438, 467, 532 :—Upper Sind, 100, 279.
Desideri, Father Ippolito (1684–1733), SJ., [I : 88 n.14], 220, 240, 512.
De Souza, Angelo (b. 1837), civ. asst. Trig., 32–3, 418, 422 :—Francis, civ. asst. Bo. Rev., 444.
Devadhanga, legendary Pk., Nepāl, 95, 502.
Deveria, Jules, civ. asst. Rev., 30 n.4, 31, 418, 440, 461.
Devi Singh, of Kumaun [II, 431], 528.
Dew, 438, 459, 464.
dhangars, from Hazāribāgh, 362, 454.
Dhārwār, Deccan, SMC., 371 :—Rev. Svy., 275, 398, 400–1 ; pl. 28 ; v. Marātha.
Dhaulāgiri Pk., 26,795 ft. [II, 87 n.5], Nepāl, 65, 81, 91–2 ; pls. 2, 4, 28.
Dholpur, Rājputāna, 190, 438 ; pls. 1, 5, 28.
Diamond Harbour, Hooghly R., 15, 24, 140, 248 ; pls. 1, 28.
Dickens, Lt.-Gen. Craven Hildesley (1822–1900), Ben. Art., cm. ; *Who Was Who* ; 276, 295, 376, 399.
Digha Ghāt & Castle, nr. Dinapore, Bihār, 18, 17, 126, 336, 368 n.2, 341, 511, 521.
Dinājpur, Bengal, Rev. Svy., 243, 246, 251, 314, 396, 434, 438, 520, 525, 528 ; pls. 1, 3, 4, 16, 28.
Dinapore, Bihār, 13, 20, 122, 336–7, 368–70, 372, 511, 521 ; pls. 1, 28.
Dir, NWF., 481, 538.
Directors, Court of, 332, 336, 527 :—orders on : GTS., xi, 23–3, 70, 72, 120, 125, 135, 139, 142, 144, 186, 193, 345, 504 :—Maps, 281, 309–10, 317, 321, 326–7 :—Personnel, 336, 338–9, 349, 354, 358, 382–3, 402, 404, 504, 526, 530, 537 :—Prof. Records, 182, 355, 307 :—Rev. Svys., 179, 275, 338, 391 :—Salaries ; 336 :—Topo. Svys., 281, 289.
Discipline, 393, 412, 437, 471, 511.
Discharge :—SGO., 354 :—GTS., 412, 439, 446, 453 :—Military, 520 :—Rev. Svys., 433–4, 443, 451 :—Topo., 524.
Discrepancies :—bdy., 271 :—Topo. svys., 178 ; v. Errors.
Diseases, 456, 458, 510 ; v. Ill-health, Sickness.
Disguise, 494, 528.
Dismissal, 271, 299, 413, 440–2, 444, 449.
Disputes :—Depti., 390–5, 496–7, 522, 530–1 :—with villagers, 377, 471, 497 ; v. Boundary.
Disraeli, Benjamin, 1st Earl of Beaconsfield (1804–81), Prime Mist., Gt. Britain, 490–1.
District or *Zillah* :—Hdqrs., 368, 483, :—Boundaries, 188, 242, 245, 256–7, 314 :—Maps, 251, 269, 277, 295, 306, 310, 313–4, 319–20, 323–6, 337 :—Officials, 245, 257, 260, 310, 322, 478–9 :—Rev. Svys., xii, 349, 436.
Districts :—of Bengal, 242, 255 :—of India, 346 :—NWF., 260, 313–4 :—Punjab, 269, 377 ; pl. 16 ; v. British : Maps.
Disturbances, 28, 32, 35, 168, 179, 271, 363, 470–4, 534 ; v. Mutiny.
Diu I., Kāthiāwār, Portuguese, 57, 74 ; pls. 1, 3, 28.
Divisions :—Admin., 242 :—Rev. Svy. units, 242 ; v. Graduation.
diwān, or Minister, 188, 232, 476.
Dixon, Lt.-Col. Chas. Geo. (1795–1857), Ben. Art., Hodson II (84–5), 191.
dobbi :—Ganges–Jumna, 105 :—Punjab, 52–3, 68, 200 ; v. Bari Doab, Jullundur, Rechna, Sind-Sagar ; pl. 16.
Doctors, 508, 518 :—Indian, with fd. party, 16, 24–5, 244, 361, 364–5, 454, 457, 460–1, 466 :—European, 496 ; v. Apothecary ; Surgeon.
Dodsworth, Wm. Thompson (1892/5–72), canal survr. [IV, 397], 184, 261, 263.
Dogs, domestic, 224, 478.
Dogras, of Jammu, 1, 141, 220.
Dollond, Geo. (1774–1852) & family [III, 522], inst.-makers, 54–5, 166, 168, 357.
Donnelly, Alex. Watt. (1837–78), 67 n.2, 418 :—Edw. Theophilus, his bro., 47 n.2, 51–2, 419, both civ. asst. Trig.
Dost Muhd. Khān (1793–1863), Amir, Afghānistān [IV, 481], 448.
Douglas, John C. (d. 1857), civ. asst. Trig., 222–4, 228–9, 282–3, 404, 419, 514.
Drainage :—Natural, 258, 282, 289 :—svy. & mapping, 6, 74, 282, 254, 265, 267, 330 :—Artificial, 68, 143, 182–3, 245, 258, 330.
Drās, Ladākh :—Fort, 187, 227, 489 :—Pass, 507 :—River, 187, 227, 232–3, 235, 506, 513 ; pls. 6, 18.
Draughtsman :—Chief, Calcutta, 82, 291, 315, 320, 342–3, 353, 428, 486 :—Head, DDn. & Simla, 238, 407–8, 436, 482 :—do CM., Bombay, 450 :—Naval, Colāba, 78.
Draughtsmanship, 121, 170–1, 176, 178, 320, 343, 421, 423–4, 427, 449, 489, 494, 496, 501, 526, 529.
Draughtsmen (dmn) :—Calcutta, 316, 341, 352–4, 359–60, 428 :—Indian, 145, 172, 320, 343, 353–4, 360, 446–7, 458 :—Temporary, 320, 323 :—Skilled, 4, 9, 209, 211–2–3, 282, 285, 289, 291, 389–9, 397, 405, 414, 424, 427, 435–7, 446, 489, 496, 531, 535 :—Rev. Svy., 280, 365 :—Topo. Parties, 169, 212, 271, 353, 387, 414, 421–2, 426–7, 480, 446 :—Hill-drawing, 176, 427 :—Litho-drawing, 326–8.
Drawing :—Offices, Calcutta, xiv, 9, 291, 307, 309, 314, 319–20, 327, 338, 349, 353–4, 404, 414, 421, 428, 536 :—DDn., 9, 206, 225, 238–9, 318, 342–3, 353, 370, 428, 436 :—with Govt. Litho. Press, Calcutta, 325–7, 370 :—Tables, 352 :—with Topo. Parties, 176, 290, 541 :—Specimens, 176, 291, 320 :—Criticism, 354, 526 ; v. Map.
Drew, Fredk. (1836–91), Geol. Svy., 1855 ; FGS. ; 1858 ; Kashmir Govt. Service, 1862–72 ; *DNB.* ; *DIB.* ; 240, 508.
Drowning, death by, 423, 439, 443, 494, 497–8, 524.
D'Rozario's Library, Calcutta, 324.
Drummond, John Gavin (1788–1851), Ben. Inf. [III, 449] ; CB., *Punjab Inscr.* (93–4) ; 309.

Duārs, on Bhutān border, 461, 489.
Ducks, 163, 235, 298 ; v. Oil.
Duhan, Harry Reilly (b. 1827), Hd. Writer & PA., 337–8, 341–2, 352, 359, 408, 507.
Dum Dum, Bengal, 257, 283, 529, 536 ; pls. 1, 28.
Dūn, of Rohilkhand & Tirhut, 252, 262.
Dunlop, James Peyton (b. 1832), 15–6, 111 :—John McGill, his bro., (1828–51), 15 ns. 1, 3, 7, 16, 19 ; both civ. asst. Trig., 419.
Durand, Henry Marion (1812–71), Ben. Engrs. [IV, 431–2], LG. Punjab, 1870–1 ; KCSI., *DNB.* ; *DIB.* ; Conolly (88/159) ; 188, 192 n.9.
Durnsford, H. C. asst. Rev. Survr., Madras, 230, 445.
Dust, 12, 14, 38, 41–2, 53, 57, 117, 192, 369, 467 :—Storm, 212.
Dwarka, Kāthiāwār, 58, 74, 500, 518 ; pls. 1, 3, 28.
Dyas, Joseph Henry (1824–68), Ben. Engrs., Conolly (90/226) ; *Punjab Inscr.*, XI. Delhi ; 68 n.5.
Dyer :—Edw. Abraham (1831–1902), 36 n.4, 419, 431 :—his bro. John (b. 1829), 35 n.2, 36 n.4, 118, 172–3, 176, 200 n.2, 205, 207–9, 211, 367, 422–4, 426–7, 429, 431, 471, 478, 496, 517, both civ. asstS. Topo :—Wm. Alfred (b. 1836), civ. asst. Trig., 31, 46, 52 n.4, 404, 419.
Dysentery, 29, 212, 278, 422, 456, 464, 482, 504, 510–1, 518.
Dyspepsia, 464, 498.

Earthquake, 43, 58–9, 488, 492, 515, 529.
Earth's crust, 133, 491 ; v. Figure of Earth.
East Coast series, GTS., XIV, 1, 2, 4, 12, 14, 22–9, 65–6, 71, 97–100, 105, 108–9, 116–8/122, 127, 132, 149, 153–5, 167–9, 172, 175, 184, 296, 338, 345–6, 361–2, 367–8, 370–1, 373, 379, 385–6, 405, 408, 413–6, 418–20, 453, 462–8, 483, 490, 492, 496, 504, 520, 525, 532–3.
East India :—Company (EIC.), 145, 307, 473, 535–6 :—Railway, 165, 437, 439 :—United Service Club, London, 523.
East-Indian, or Anglo-Indian, dmn. & asstS., 242, 320, 328, 353–4, 446, 451, 501, 517, 542.
Eastern :—Archipelago, 145 :—Frontier Series, GTS., 2, 11, 31–2, 99, 198, 415–6, 418, 468, 510.
Eclipse of Sun, 380, 492, 500, 502–3, 512, 515, 534–5, 540.
Economy, XIV, 5, 12, 101, 107, 109, 114, 347, 349, 360, 447, 449 ; v. Retrenchment.
Eden, Ashley (1831–87), BCS., 1852 ; LG. Bengal, 1872–82, 489.
Education Dept., 424, 432, 498 :—Classical, 492 :—Lacking, 426, 435, 524.
Edwards, Wm. (1816–90), BCS., Supt. Hill States & DC. Simla, 200.
Egerton, Capt. John Francis (1810–46), Ben. Art. [IV, 433], 264.
Electric :—Battery & Cable, 357 :—Signals, 537 ; v. Telegraph.
Electricity, 223, 514.
Elements, GTS., 124–5, 132 ; v. Figure of Earth.
Elephants :—Baggage, 15–6, 172, 200, 338, 362, 364, 371–4, 468, 477, 483, 495 :—death or sickness, 373 :—pregnancy, 372 :—riding, 260, 504, 518, 527, 529 :—wild, 27, 207, 258.
Ellichpur, Berār, 178, 481, 483, 518 ; pls. 1, 3, 28.
Elliot, Chas. Morgan (1815–52), Mad. Engrs. [IV, 117–9] ; Conolly (100/160) ; 114–5, 527.
Ellis, Capt. Geo. (1806–43), Ben. Art. [IV, 433], 264, 422.
Ellison, James (d. 1884), civ. asst. Trig., 28, 29 n.2, 174, 419 :—Wm., civ. asst. Rev., 270 n.5, 433, 440.
Embankments, or *bunds*, 24, 249, 264–5, 324, 525 :—Supt. of, 258 n.2.
Encyclopaedia Britannica, XXV, 78, 540, 544.
Energy, 416, 425–7, 448, 489, 492, 523–4, 528–9, 532, 502, 544 :—want of, 247, 390–1, 402, 410, 415, 434, 438, 449, 462, 491, 525.
Engineers :—Asst., 500 :—CIVIL, 180, 182, 210, 397, 404, 407, 508 :—Consulting, 74, 181–2, 495, 531 :—Executive, 497 :—Suptdg. (SE.), 309, 339, 387–8, 525 :—Rly., 1279, 322, 374, 510 :—Dept., 68 :—Duties, 384, 519 :—MIL. :—Cadets, 338, 524 :—Offrs., 4, 6, 134, 139–41, 162, 180, 194–5, 198–253, 320, 379–82, 384, 387, 390, 392, 397, 493–4 :—Bengal, 217 :—Bombay, 8, 54, 191–3, 380, 391, 494, 518 :—Madras, 179–80, 383, 519 :—Troops, 518, 534 ; v. Chief.
Engineering :—College :—Bengal, 257, 397, 529, 543 :—Lahore, 446 :—Madras, 497 :—Putney, England, 423 :—Dept., Bombay, 524 :—Projects, 3, 4, 68–9, 285 :—Maps for, XV, 214, 285, 320 ; v. Roorkee.
England:—Education 437, 440, 443 :—Appts. 357:—Leave, XIII, XV, 416, 430–2, 439–45, 471, 504, 519, 523, 526 :—Maps printed, 9, 326–7 :—Repair of Insts., 164 :—visits, 522, 537 :—retirement, 520.
English :—Language, 113, 357, 446, 448, 465, 522 :—Sword, 543 :—Winter, 503.
Engraved Maps, 9, 181–3, 239, 250, 290, 308–9, 319, 324.
Engraver, 171, 319–20, 330, 332 n.5.
Engraving :—Atlas Sheets, 309–11, 540 :—SGO,. Calcutta, 352–3 536 n.1 :—on Stone, 328–9.
Errors :—Accumulated, t-page, 98, 101–2, 119, 130, 204, 286, 298 :—Clerical, 117 :—Closing, 42, 107, 109, 234, 286 :—Distribution, 21, 49, 63, 67, 90, 101, 128–9, 132–3, 521, 540 :—Instrs. 98, 115–6, 164, 166, 160, 286 :—Probability, 122, 286 :—Trgn. 28, 128, 130, 132, 166, 171, 198 ; v. Discrepancies.
Errors in :—Astr. Obsns., 102, 147 :—Plotting of Charts, 121, 507 :—Comps, 126, 128 :—GTS., 11, 281, 404, 417 :—Geogl. Position, 146–7, 507 :—Heights 48, 62–3, 66–7, 72, 74–5, 93–4, 98 :—Levelling, 77–80, 157, 160 :—Mapping, 198, 312 :—Perambulator meast., 161–2, 169 :—Printing, 124 :—Ray-Traces, 119 :—Rev. Svy., 246–7, 251, 255, 269, 271, 294, 298, 303–5, 434, 538 :—Maps, 270 :—Time Signals, 357 :—Topo. Svy., 198, 281 :—Traverse, 215, 251, 298, 438 :—Trgn., 11, 22, 56, 102, 132, 287 :—Vertical Angles, 64 ; v. Identification of Peaks ; Marks.
Escorts, 44, 183, 524 :—Mounted, 179, 475 ; v. Guards.
Establishments :—Deptl., 376 :—GTS., 24, 369 :—Madras, 363 :—Rev. Svys., double or single, 365, 396, 455 :—Topo., 363.
Estates, *mahāls*, or *zamindaries*, 8, 184, 244–5, 251, 253, 263, 280, 285, 292, 294 :—Bombay, 275 :—fragmentation, 300–1 :—Town, 259 :—Govt., Calcutta, 183, 249–50 :—under permt. settmt., 293–4, 300 ; v. Boundaries.
Etāwah Dist., NWP., 190 :—Map, 325 :—Rev. Svy., 296 ; pls. 1, 16, 28.
Europe :—Journeys to, 184, 428, 496, 510, 540 ; v. England ; Furl.
European :—Artisans, 164, 357 :—ASSTS. ; GTS., 419, 446 :—Lithо-Printers, 334, 357 :—Rev. Svy., 216, 242, 276, 278, 302, 365, 439–43 :—Topo, 198, 208, 210, 262, 423, 425, 430–2, 447 :—Dmn., 343, 354 :—Doctors, 464 :—Explorers, & Travellers, 83, 315, 448, 528, 536:—Geogrs. & Geodts. XIII, 240, 540 :—Nationals, 170, 182, 468, 473–4, 481, 493, 528, 536 :—Survrs., 218–9, 237, 244, 276, 435, 464, 472 ; v. British.
Evans :—Henry Lloyd (d. c. 1889) ; Bo. Inf., 1837–61 ; Mālwa BAU. Corps, 1842–61: 189 :—Wm. Edwyn (1818–d. after 1888) ; Bo. Inf. [IV, 369], Deccan, Rev. Svy., 401.
Everest, Sir George (1790–1866) ; Ben. Art. [IV, 433–43] ; SG. & SYS., 1830–43 ; FRS., CB., Kt., *DNB.* ; *DIB.* ; IX, 338–9, 342, 344, 379–82 :—Administrator, XIII, XIV, 1, 3, 94, 201, 281, 321, 365–6, 376 :—Disciplinarian, 390–1, 497, 530 :—Fd. work, V ; 54, 66, 81, 105, 118, 120, 336, 414 :—Geodesist, XV 10–1, 54, 63–4, 70, 97, 100–1, 103–4, 106, 108, 112, 115–6, 121–5, 128, 130, 132–5, 137, 285–6, 346, 390, 522, 534 :—Geographer, 238, 288, 307, 319, 331:—Ill-health, 417 :—Insts. 130, 148, 150, 153, 158–61 :—Personnel, 357, 426, 446, 461, 520, 530, 542 ; v. Arc Books.
Everest, Mount :—XV, 17, 85–6, 91–6, 147, 235, 416, 501–2, 510–1, 514, 519 :—Ascent of, 1953, 96 :—Height, 91–4, 136, 521 :—Identity, 91, 94–6 :—Name, 92, 94–6, 522 ; v. Armstrong ; Peaks.
Ewan, Thos. Wm. (b. 1931/2), civ. asst. Rev., 433, 440.
Examination, or personal test ; Civ. AsstS. ; GTS., 344, 403–5, 425, 501 :—Rev. Svy., 436–7, 439 :—Topo. Svy., 426 :—of field work ; v. Check ; Inspection ; *partial*.
Executive :—Engrs. or Officers, PWD., 316, 318, 375 n.5, 469 :—Survrs. in ch., 121, 346, 380–1, 434.
Exhibitions :—Calcutta, 1872, 518 :—London, 1862, 319, 330–1, 532 :—Paris, 1867, 532.
Expenditure :—Allotment, 347–8, 434 ; v. Budget.
Expenses :—Compg. Office, 355 :—GTS., 2, 16, 32, 39, 70, 361–2, 446 :—Geolgl. Research, 143–4 :—Mapping, 317 :—Private, 31, 375, 411, 429, 437, 522, 534 :—Rev. Svy., 67, 242, 245–6, 274–7, 350 :—Svy. Expns., 507 :—Topo. Svy., 218, 324, 363 ; v. Travelling.
Experiments, 115, 140, 243, 250. 2 5.
Exploration, 157, 167, 187, 448–9, 507, 515–6.
Explorers, 147, 220, 380–1, 448–9, 508, 516, 527, 540.
Explosions, 493, 493, 539, 543.
Extravagance, 289, 410, 438 ; v. Debt.
Eye-sight, 79, 206, 223, 279, 353–4, 356, 394, 451, 492, 520, 529, 315, 533, 535.
Eyre, M Gen. Sir Vincent (1811–81), Ben. Art., Hodson, II (149–50) ; Supt. Ishāpur Powder Factory 1858–61 ; IG. Ordn., Calcutta, 1862 ; CB. ; KCSI., *DNB.* ; *DIB.* ; 537.

Face, of Theodolite, change, 67, 82, 88–9, 114–5, 286–7.
fakirs, or beggars, 51, 249, 517.
Fall, accidental, 226, 446, 454, 517.
False Point, Orissa [II, pl. 4], 173–4, 526.
Families & Wives :—British soldiers, 48 :—European, 484 :—SVY. AsstS., 369, 411, 413, 424, 458, 483, 437, 518 :—Followers, 446 n.3, 452 :—Officers, 393, 395, 488–535, *passim*.
fanam, coin, 42 to one *pagoda* [II, 330 n.1], 347.
Faridpur, E. Bengal ; Rev. Svy., 243, 253, 256 ; pl. 1.
Farmers, or contractors, of revenue, 292.
Farrell :—Capt., 518 :—Robt. Dennis (b. 1853) ; civ. asst., Topo., 179 n.4, 431.
Farrukhābād, NWP., Rev. Svy., 263, 520 ; pls. 1, 3, 16, 28.
Fatehgarh, NWP., 371, 501 ; pls. 1, 4, 28.
Fatehpur, NWP., 488 ; pls. 1, 16, 28.
Faulty :—Maps, 315, 318 :—SVY. GTS., 404 :—Rev., 6, 241, 246–8, 255, 258–9, 263, 270–2, 293, 303–5, 396, 474 :—Rev., civ. admin., 269 :—Topo., 197–8, 211–283, 290.
Fell, Wm. (1813–56) ; IN. [IV, 265] ; Pegu & Martaban, 1847–50 ; *IO Cat.* (592–3), 196.
Fergusson, Edw. Francis Tierney, IN. Markham (288, 465) ; FRAS., 1851 ; *IO Cat.* (648) ; Dmn. Colāba Obsy., 1851–64 ; *Clan Fergusson, I* (555) ; 73, 139 n.2.
Ferozepore, Punjab, 3, 42, 44, 50, 79–80, 338, 372, 415, 484, 488, 491–2, 504, 509, 511, 541 :—Rev. Svy., 269–70 ; pls. 1, 3, 5, 16, 28.
Fever :—Ague, 467 :—Bilious, 457–9 :—Jungle, 459, 461–3 :—Miasmatic, 510 :—Treatment, 459–60, 462, 464–6 :—Akyab, 243 :—Assam, 2, 29–31, 183, 369, 373, 461, 519 :—Bengal, 11–2, 16, 18, 20, 253, 456–7 :—Delhi, 265 :—East Coast, 25–8, 168, 171, 173, 178, 367, 379, 421–2, 467, 490, 496, 500, 520, 526, 533 :—GTS., 365, 456–7, 501 :—Gujarāt, Bombay, 55, 460–1, 467 :—Hqrs., Calcutta, 354 :—Punjab, 210, 271, 516, 536 :—Sind, 278, 438 :—South India, 365 :—*tarai*, 501, 541 ; v. Malaria.
Fieldbooks :—GTS., 44 :—Rev. Svy., 249, 255, 267, 277, 300, 303, 322–3, 346 :—Topo., 196, 215–6, 285, 288 :—Loss or Destruction, 267, 305, 346.
Field Season, 365–8, 459, 504 :—Short, E. Coast, 26–7, 38 :—Early close, 395 :—Engagement of *khalāsis*, 167, 169, 175, 260–1, 290, 452, 463–4, 466–7, 526 :—Punjab, 215 :—Summer in Mts., 202, 221, 226, 231, 468, 498 :—prolonged, 278, 366–6 :—resignation forbidden, 403 :—*tarai*, 261 ; v. Sunday.
Field Sections, 177, 205, 231, 239, 267, 289–90, 513 ; v. Planetable.
Fields, cultivated, 468 :—Boundaries, 275–6 :—Map ; v. *shajrah* :—Meast., 264, 280, 292–4 :—Register, 279–80, 293, 301–2 :—Rev. Svy., 7–8, 191, 242, 251, 272, 292–8, 299–301 ;—Svy., or *khasrah*, 300–2 ; v. *khasrah*.
Figure of the Earth, XIII, XIV, 85, 92–3, 124–6, 130, 133–4, 136, 282, 491, 520, 540 :—Everest's Constants, 124–6.
Finance Dept., 236, 378, 536.
Fire ; burning, 163, 223, 230 :—Destructive, 148, 163, 250–1, 364, 520 n.1 :—Forest, 28, 468 :—protective against malaria, 464, 466 :—Signal, 57.
Fire-arms, 256, 474–5, 486.
Firewood, 21, 206, 229, 231, 234 ; v. Fuel.
Firminger, Rev. Dr. Thos. Aug. (1812–84), Ben. Chpn., 1845–68; artist & auth. of *Gardening in India* ; *DIB.* ; 492.

Fiscal divisions, revenue, 285.
Fisher, Thos. (1798–1847), Ben. Inf. [III, 447–8], will, 29, 312, 461.
Fitzgerald, Maj. Wm. Robt. (1798–1844), Ben. Engrs. [III, 448], 497.
Fitzpatrick, John (b. 1806), civ. asst. Rev. [IV, 443], 241, 244, 503–4, 519, 534, 433, 441, 520.
Flag:—man, 207, 228, 287, 863, 454–5; v. Signalmen:—staff, 207.
Flags, Signal, 24, 104, 198, 252, 282.
Fleming, Dr. Andrew (1822–1901), Ben. Med. 1845; FRCS.; Crawford's *Roll* (B. 183), 144.
Floods:—Coastal, 41, 58, 78:—from rains, 19, 24–6, 107–8, 231, 260:—from rivers, 31, 49, 52, 60, 105, 110, 259, 274 n.3, 278, 871, 873, 468, 515, 526; v. Indus.
Fogs, 25, 29, 132, 256, 467–8; v. Cloud; Mist.
Followers:—GTS., 31, 44, 337, 841, 861, 864, 452, 463, 472, 476, 482, 500, 507:—Topo. Svys., 168, 875, 459, 486, 517; v. *khalasis*; Lascars.
Food:—Cooking, 478:—Eating, 183, 252, 279, 465, 478, 477:—Supplies, 2, 174–5, 229, 236, 455, 465–6, 476, 518.
Foot:—paths, 406, 468, 478, 504:—wear, 39.
Ford:—St. Clair (1830–96), Bo. Inf. added surname St. Clair 1878, Dep. Collr., Shikārpur, 1867, 278:—Robt. Benoni (1837/8–63), *mulazim*, Assam Rev., 441.
Foreign:—Correspondence, SG., 342:—Dept., G G D.), 189, 489, 507–8, 511:—Service, unpopular, 452.
Forests:—Assam, 31, 468:—Arakan, 434, 463:—Bengal, 15, 246:—Dūn, 207:—E. Coast, 23, 27, 526:—Himālaya, 271:—Sind, 192–4, 276:—*tarai*, 18, 252:—Clearing, 263:—Dept. 276, 443:—Grants, 258, 260, 263:—Limits, 6, 188, 282:—Mapping, 171:—obstruction to svy., 840, 489:—svy. by rev. surveys., 258–60, 263, 266, 483:—Unhealthy, 461, 467; v. Jungle; *sal*, *tarai*.
Forms, computing, 91, 121–2, 127, 344.
Formulæ, 90, 92, 121–3, 128, 130, 503, 522, 534.
Forsyth, Sir Thos. Douglas (1827–86), BCS., missions to Yārkand & Kāshghar, 1870–1, 1873–4, CB., KCSI.; *DNB.*; *DIB.*, 506.
Fort William, 70, 139–41, 164; v. Time-ball.
Forts, blown up, 397, 543:—ruined, 48:—local strongholds, 170, 185:—survd. or sketched, 51, 490.
Foy:—A., 275 n.2, 433, 441:—Chas. Christopher (b. 1809), 269, 433, 435, 441:—Edw., 441:—J., 269; all civ. assts. Rev.
France, 65, 339.
Francke, Rev. A. H., Moravian Mission, Ladākh, c. 1890–1905; auth.; Burrard & Hayden (16, 162); xxv, 240.
Franking of letters, 374, 452.
Franklin, James (1783–1834), Ben. Cav. [III, 448–9], 188.
Fraser:—Geo. John (1800–42), Ben. Cav. [III, 449], 258:—James (1804/5–63), civ. asst., Bo. Trig. [IV, 386], 38 n.3, 51, 54, 418–9.
Fraudulent svy., 255, 304, 438.
Frazer, H., Calcutta lithographer, c. 1860; dau. aged 7 y., d., Serampore, 19–10–62; 239; pl. 15.
French:—Geodesists, 516:—Language, 283, 522:—Possessions in India, 247–8.
Frere, Sir Henry Bartle Edw. (1815–84); 1st Bart.; Ch. Comnr. Sind, 1850–61; Govr. Bombay, 1862–7,; Cape, GA., 1875–80, GCB., GCSI.; FRGS., 1850; FRS., 1873; *DNB.*; *DIB. GJ*, 50, 1884 (55); 193–4, 470.
Frome, Gen. Edw. Chas. (1802–90), RE.; Conolly (24/579); FRAS., SG. S. Australia 1839–49; Mauritius, 1851–8; Lt.-Govr., Guernsey, 1869–74; 339.
Frontier:—British, 307:—NWF., 216:—SW. Bengal, 495:—Tribal, 473, 475.
Frost, 45, 203, 207:—bite, 207, 489, 507.
Frost, Rev. Dr. Percival (1817–98), mathn., 2nd wrangler, St. John's Coll. Camb.; FRS., 1883, DSc., 1883. *DNB.*; *Who Was Who*; 502.
Fruit trees, 14, 23–4, 60, 468, 478, 504, 527.
Fuel, 108, 206, 236, 491, 506:—lack of, 467; v. Firrwood.
Fulcher, Robt. Page (1800–84), Ben. Inf. [III, 474], 497 n.4.
Furlough, 3–6, 20, 31, 54, 172–3, 176, 237, 241, 243, 251, 254, 257, 269, 279, 331, 336, 340, 348, 379, 382, 386, 391, 396, 399, 416–7, 426, 489 to 526, *passim*.
Fytche, Gen. Albert (1820–92), Ben. Inf.; Ch. Comnr., Burma, 1867–71; CSI. 1868; *DIB.*; 196.
Fyzābād, NWF., 12, 185; pls. 1, 28.

Galton, Sir Francis (1822–1911); scientist, FRS., Kt. 1909; *Ency Brit.*; *Who Was Who*; 540.
Gandak R., Bihār, 17, 118, 185, 252; pls. 1, 4, 28.
Ganges R., 12–6, 254:—Canal, 318, 490, 531:—changes of course, 257, 262, 312:—Boat traffic, 336, 341, 355, 372, 499, 521, 535:—Rev. Svy. both banks, 12–3, 118, 262:—Upper, 206–8, 393, 423, 496, 517:—Lower, xiv, 97, 99, 105, 161.
Gangotri, Upper Ganges, 207; pls. 3, 4, 28.
Ganjam, E. Coast, 167:—Climate, 462–6:—Coast, 370:—Halpin's svy., 4, 22, 167, 462, 504, 525:—& Orissa Topo. Parties, 28, 172–7, 184, 244, 338, 344, 363–4, 370, 374–5, 385–7, 396, 416, 421–2, 429, 454–5, 483, 495–6, 500, 504, 526:—& Orissa Svy., 1, 118, 143, 167–77, 285, 288, 291, 363–4, 527:—Town, pls., 816, 28:—Rev. Svy., 280:—Trgn., GTS., 28–9, 31, 500.
Garden, Wm. (c. 1790–1852); Ben. Inf. [III, 450]; QMG.; ix, 1961, 315 n.7, 317.
Garden:—Reach, Calcutta, 183:—lands, Bengal, 14, 24, 174.
Garhmuktesar, Ganges ford, Meerut Dist., [IV, pls. 4, 11], 341, 355, 370, 372.
Garhwāl, Himālaya [III, pls. 5, 6; IV, 17], 16, 84, 81, 147, 157, 167–8, 200, 206–7, 262:—Maps, 319, 324:—Tehri, 496:—Svy.; v. Kumaun.
Garling, Capt. James (1784–1820); Mad. Inf. [III, 450–1], 177, 280, 846.
Garo:—Hills, Assam, 241, 243, 253–4, 312, 488, 513 pls. 1, 16, 28:—Tribesmen, 253.
Garth, Douglas (1852–1900), solicitor, Hon. Sec. London Philatelic Soc.; obit., *Journal* of Jan. 1900, 335.
Gartok, Tibet, 145, 528; pl. 4.
Gaskoin, Clarke Avery (1829–58) Ben. Art., 185.
Gauhāti, Assam, 2, 29, 31–2, 120, 312, 362, 369, 477, 482, 484, 489; pls. 1, 3, 28 (Gowhatty).
Gaurisankar Pk., 28,440 ft., Nepāl, 95, 147.
Gauss, Chas. Fredk. (1777–1855), German mathn. [IV, 483], *Ency Brit.*, 128.
Gaya, Bihār, Rev. Svy., 5–6, 241, 255; pls. 1, 3, 16, 28; v. Bihār.
Gazetted Officers, 434, 444.
Geese, 163, 235; v. Oil.
Geneste, Capt. Maximilian Goodwin (1831–58), Ben. Engrs., Conolly (92/276), 141.
Geodesists xiii, 71, 281, 337, 340, 380, 387, 417, 532–3, 540.
Geodesy, 137, 284, 520, 541.
Geodetic:—Experience, xv, 340:—Instns. 98:—Opns. xv, 81, 85, 286, 340, 390, 392–4, 397, 414, 417, 424, 514, 533–4:—Principles, 284, 336, 503:—Subjects, 342, 497, 520, 530.
Geographer:—Company's, xiii, 9, 182, 309–10, 316, 330:—to Queen, 512.
Geographical:—Compilation, 120–1:—Congress, Paris, 1875, 516:—Control, 2, 7, 9, 281, 295:—Dept., 10., 512:—Detail, 120, 176:—Knowledge, 220:—Material, 120, 146, 191, 280:—Positions, 68, 84, 87, 90–2, 122, 125–7, 169, 287, 295:—Problems, 95:—Svys., xiii, xiv, xv, 52, 157, 180, 258, 346, 422, 528.
Geographicus Indicus; Index to place names, J. F. Baness, Calcutta, 1881; 490.
Geography, of India, 146; v. Physical.
Geoid, 93–4.
Geological:—Dept., 142–4, 311, 323:—Features, 213:—Infm., 187, 526:—Maps, 143, 145:—Soc. of England, 142, 526:—Specimens, 142–4, 146, 526:—Survs., Bengal, 142:—Svy., I, 69, 143, 318:—Dept. India, 535.
Geologist, 142–3, 171–2, 529.
Geology, 142–6, 210, 488, 513, 526–7, 529, 531–2.
Geophysics, 520.
Gerard, Alex. (1792–1839), Ben. Inf. [III, 451–2], *DNB.*; *DIB.*, will, 188:—Dr. James Gilbert (1793–1835), Ben. Med. [IV, 444–5], 204 n.2.
German:—Embassy, London, 144:—King, 144:—Legion, Hanover, 500:—Litho. Stones, 329:—Scientists, 95, 145–7, 527–8.
Ghāzipur, NWF., 337, 369; pls. 1, 3, 16, 28.
Ghulam Kadar, dmn., 238–9, 291, 343, 360.
Giberne, Capt. Henry (1810–48), Bo. Art. [IV, 445], 450.
Gibson, Andrew John (b. 1842), & J. B., both civ. asst. Rev., 433, 441:—Robt., mathn. & auth., 297.
Gilbert & Sons, inst.-makers [IV, 483], 160, 299.
Gilchrist, Dr. John Borthwick (1759–1841), Ben. Med. [I: 337]; *DNB.*; *DIB.*, 321.
Gilgit, Upper Indus, 48 n.3, 187, 226–7, 232, 237, 240, 481, 515, 531, 544; pls. 1, 5, 6, 28.
Gill, Sir David (1843–1914) astr., AR. Cape Town, 1879–1906; KCB., 1900; *RS Procs.*, xcii (xxvi–xliii); *RAS* (MN), 75 (286) *Who Was Who*; 152.
Gillies, Dr. Josiah Dashwood (1826–64), Mad. Med., MRCS.; Crawford, M. 1288; 278.
Glaciers, 5, 89–90, 145, 187, 203, 206–7, 224–6, 229–30, 235–6, 239, 505–6, 512–3, 515, 526, 532.
Glossary, Rev. Svys. [I: 335; IV, 203–6], 241 n.1.
Glynn, Wm. (b. 1821), civ. asst. Trig. [IV, 384–5], 11–12, 231, 418.
Goa, W. Coast, 55, 523; pl. 28.
Goālpāra, Assam, 30–1, 120, 242, 253, 461, 476–7, 519:—Rev. Svy., 312, 434; pls. 1, 16, 28.
Goats, 203, 205, 364, 481.
Godāvari:—River, xiv, 29, 416, 490, 518:—Irrigation project, 279:—Dist., 280, 417; pls. 1, 3, 28.
Gogra R., Oudh, 12–3, 17, 118, 185; pls. 1, 4, 16, 28.
Gold 526:—Medal, v. Royal GS.
Goldsmid, M.Gen. Sir Frdk. John (1808–1906), Mad. Inf. [IV, 48]; ix:—Henry Edw. (1812–55), Bo. CS. [IV, 445], *DNB.*; *DIB.*, 7, 275–6, 898.
Gomes (Gomez), A. D. R. (b. 1831/2), Geol. Svy., Khāsi Hills, 1849–52; Ben. uncov.; Dep. Collr., Sundarbans, from 1852; Comnr. 1866–84:—Markham, 1871 (302–3), 142, 441.
Goodwyn, Henry, senr. (1807–86), Ben. Engrs., Conolly (87/124), Hodson, III (283/4), 162, 164, 358:—junr. (1831–59), Ben. Engrs., Conolly (92/280), 217.
Goomsur, Ganjam, 22, 174, 176, 378–9, 462, 504; pls. 1, 16, 28.
Goorkhas, 2nd, Sirmoor Rifles, 376, 491 n.1, 512; v. Gurkhas.
Gora Merdl. ser., GTS. (pls. 3, 4), 2, 12–3, 17, 67, 82, 126, 128, 184, 185, 809, 361, 365, 379, 414–5, 457, 476, 496.
Gorakhpur:—Collr., or Dep. Comnr., 185, 264:—Dist., 34, 81–2, 84, 104, 185, 263, 418, 488:—Rev. Svy., 263, 246, 500:—Town, 12, 17, 185; pls., 1, 3, 16, 28.
Gough, Lord, Hugh (1779–1869), 1st. Viscount, M. 1862, C in C, India, 1843–9 [IV, 260]; *DNB.*; *DIB.*, 522.
Gour Ruins, Mālda Dist., Bengal, 245.
Govan, Dr. Geo. (1787–1865), Ben. Med. [III, 40 n.6; 524], Supt; Bot. Gdns. Sahāranpur, 1817–28; will.
Government:—Depts. xiv, xv:—Gazette, 323:—of India, 133–8, 142, 145, 195, 238, 264, 276, 278, 291, 340, 350, 476, 483:—Supreme, xiii, 313, 317, 320, 429, 475, 496–7, 507–8, 526:—Local & Provl, xiii, xiv, 351, 476, 534, 536:—Property, Loss, 372; v. Bengal; NWF.; Punjab.
Governor:—General, 142, 183, 238, 269, 319, 333, 337, 349, 507, 526:—in Council, 139, 189, 322, 347, 394, 507, 517:—Lieut. Govr., 347:—Bengal, 175, 183, 531:—of, 532, 536:—Punjab, 337, 396–7, 540; v. NWF.
Graduation of Insts.:—34, 150, 152, 155–6, 162–3:—Faulty, 115–6, 156:—by hand, 152:—of level scale, 159:—by Troughton & Simms, 56, 153, 162–3:—worm, 150, 162.
Grains, food, 40, 466, 479; v. *kharīcha*.
Graham, John (1801–58), Hd. Dmn. [IV, 445], 320, 323, 353–4, 356, 427:—Walter Rose Malcolm, his son (1821–60), Hd. Dmn., Rev., 349, 354, 359, 505.
Granite, 208, 362.
Grant:—Fredk. (b. 1856), civ. asst. Rev., 441:—H. M., civ. asst. Bo. Rev., 444:—Sir John Peter (1807–93), BCS., 1828–67, KCB.

1862; LG. Bengal, 1859–62; *DNB.*; *DIB.*, 353 n.4, 581–2:—Peter Warden (1794–1823), Ben. Inf. [III, 454–6], vii, 185–196.
Grapes, 203.
Grass:—cutters, 374, 473:—fodder, 254:—High, or reeds, 14, 252, 258, 261–2, 456, 468:—Jungle, 6, 49, 79, 120, 260, 278:—low, spear, or thorn, 39–40.
Graticule of map, xiv, 123, 125, 309, 317, 330.
Gravity:—Deflection, 124:—Force, 134, 503, 540:—Obsns., 94, 137, 490; *v.* Deflection; Plumbline.
Gray, Ernest, watchmaker [III, 218; IV, 483], Calcutta, 1824; 40, 164.
Grazing rays, 48, 53, 57, 62–7, 75, 102, 287.
Great Arc, GTS., xiii, xiv, 1, 2, 11, 16, 20, 49, 54, 64–7, 75, 80–1, 91, 98, 101, 104–5, 124–5, 127, 130, 133–7, 148–50, 153, 155, 177, 179, 188, 190, 268, 295, 309–10, 315–6, 365–6, 370, 402, 414–6, 469, 490, 509, 511, 516, 521, 523, 530, 541:—Comps., xiii, 124–5, 127–8, 414, 486:—Geogl. Positions, 125:—Heights, 66–7, 72, 520:—precision, disputed, 133–4, 530; *v.* Arc Books.
Great Indus ser., GTS.; xiv, 3, 37, 41–2, 44–50, 53, 74, 76, 78, 80, 86, 99–100, 109–11, 129, 133, 138, 151, 154, 216–7, 228, 279, 287, 361, 367, 370, 415–6, 446, 448, 467, 482, 484, 490, 503, 509–11, 534, 538–40.
Gt. Longl., or Karāchi, ser., GTS., 2, 19, 34–5, 37–43, 45, 49–50, 55–7, 59–60, 67, 72, 74–5, 97–100, 109, 113, 117, 122, 129–30, 132, 148–50, 193, 266, 315, 343, 345, 361–2, 376, 379, 392, 405–6, 467, 469, 523, 532:—Personnel, 421–2, 510, 532–4:—Comps. 122–3.
Gt. Trigl. Svy. (GTS.), 1–3, 8–68, 72–80, 95, 140, 191, 220, 253, 281, 411, 467:—*Account*, pub. (*GTS*), 80, 129, 137, 339, 516, 540:—520:—Comps. 91, 123, 136:—Control of Rev. & Topo., xi, 2, 4, 8–9, 22, 36–7, 131, 179, 188, 209–10, 250, 280, 282, 295–7, 309–10, 312–3, 337, 449:—Maps, 125, 281, 309–10, 313–4, 317, 438:—Finance, 345–7:—High Priority, 10, 282:—Less accurate sections, 21, 281, 390, 516, 530:—Office Premises:—Recess Qrs., 365:—Reduction of Results, 21, 23, 125, 129, 133, 417, 502–3, 540:—Reports & Records, 121, 345–6:—Topo. Detail, 184, 281; *v.* Accuracy; Charts DDn.; Geogl.; Instns.; Insts. Points; Prncpl. Stns.; Rev. Svys.
GTS. opns. Bombay, 34–61, 192:—Burma, 5, 198, 492, 510:—Indian States, 191:—Upper India, 9, 34, 200:—Sind, 192, 194, 277.
GTS.:—Staff; 10, 22, 449, 383, 391, 496–7:—STS., xi, xiii, 32, 113, 129, 151, 154, 340–1, 356, 370, 380–1, 388–9, 417, 516, 525 538–40, 542; *v.* SG., combined role:—MILITARY OFFRS:—Appts., 22, 339, 363, 379–81, 387:—Biog. Notes, 490–3, 496–8, 500, 03 513–6, 518–9, 522–5, 529–35, 537–42:—Bombay, 382, 390–1:—Casualties, 336, 379–84:—Nominal Roll, 399:—Promotion 381–2, 387, 524:—Removals, 391, 395, 497, 530–1:—Shortage, 382–4:—CIVIL ASSTS., iv, 201, 414–8, 422–3, 428–9, 501–3, 505–11, 516–8 :—Appts., 402–5, 497, 509, 542:—Casualties, 402–4, 408, 415:—Nominal Roll, 418–20:—Shortage, 403; *v.* Allces.; Disputes; Explorers; Parties; Sub. Assts. Training.
Greenough, Geo. Bellas (1778–1855); son of Geo. Bellas; took g. father's name, Greenough, whilst at Eton Coll., 1795; 1st Presdt. Geol. Soc., 1811–8; Presdt. RGS., 1839–40; *DNB.*; 143.
Greig, John & Son, of Edinburgh, exported printing machines to India, 329.
Grid, of triangles, xiv, 1, 21, 67, 97, 100–1.
Grierson, Sir Geo. Abraham (1851–1941), BCS. 1873–1903, KCIE. 1912; OM., D Litt., Dublin, 1902; auth. *Linguistic Survey of India*; 240.
Griffith, Wm. (1810–45), Mad. Med. [iv, 446], botanist, ix, x.
Griffiths, M Gen. Clement James (1838–1915), Ben. Inf., 1856, 400.
Grindall, 2 Lt. Fredk. Chas. (1825–49), Ben. Engrs.; dro., Attock, 18–7–49; Conolly (90/236); 217.
Grindlay & Co., Bombay Agents [II, 403], 538.
Grote, Arthur (1814–86), BCS., 1833–68; FRS., FLS., FZS., *DNB.*; *DIB.*; Bd. of Rev., Ft. Wm., 1861–8; 250.
Grumblers, 418, 510.
Guards:—Mil., 341, 376–8:—with SG., 337:—with GTS., 18, 28, 37, 45, 48, 197, 222, 361, 376–7, 473, 484, 454, 466, 514:—with Topo. Parties, 4, 168, 179, 218–9, 364, 373, 377–8, 463, 471, 484, 508:—over Buildings or Insts., 113, 158, 162, 376, 473, 499:—Civil, or tribal, *najib* or *sebundi* [IV, 413], Hodson, I (xxix–xxx), 145, 377; *v.* Barkandaz; Escorts; Oudh; Police.
Gubbins, Chas. Bathoe (1809–66), BCS., 1829–59, 302 n.5.
Guides:—Local, 117, 194, 475, 485, 528, 539:—Mil. Corps., NWF., 37, 216 n.7, 216 n.4, 475, 511:—QMG.'s survrs., 192.
Gujarāt, Bombay, 146, 191–2, 366, 460, 467:—Longl. Ser., GTS., 54–6, 57–8, 60–1, 473 n.1:—Rev. Svy., 494, 521:—Topo. Svy., v, 8, 57, 192, 449–50, 492:—Trgn., 2, 3, 54, 57, 73, 97, 103, 118, 367, 500; pls. 1 (Goorrat), 28.
Gujrānwāla, Punjab, 7, 273–4; pls. 1, 5, 16, 28.
Gujrāt, Punjab:—Battle, 21–2–49, 33 n.4, 214, 316, 499, 524, 539; Dist., 273, 530; pls. 1, 5, 6, 13, 16, 28.
Gulāb Singh, Dogra Rājput (1792–1857), Mahārāja of Jammu & Kashmir, 1, 4–5, 35–6, 52, 186, 210, 220, 224, 472, 480–1, 485, 514:—Territories of, 4–5, 187, 209, 210, 220–2, 230, 236, 273, 489, 493, 496, 506–7, 515–6, 524, 531; *v.* Jammu:—Death, 5, 230, 481, 485, 515; *v.* Kashmir, Mahārāja; Treaties.
Gulatee, Behari Lal (b. 1900), Mathn.; 8 of 1., 1926–58, MA. Camb.; 96.
Gulmarg, Kashmir, 228, 490; pl. 13.
gumashta, agent or steward, 280, 476.
Gun:—carriage, 161:—powder, 41, 493, 539:—Shot, sporting, 479, 484:—shots, fired, 215, 219, 539.
Guns, of Artillery, 481, 484.
gunta, unit of measure, 276.
Guntūr, Madras, 512, 535; pl. 28 (Guntoor).
Gurgaon Dist., S. of Delhi, 265, 508.
Gurhaghar merdl. ser., GTS., 3, 49–51, 53, 56, 80, 111, 233, 297, 534:—HS., 86, 222, 417, 513–4, 523, 534; pls. 3, 5, 6.
Gurdāspur, Punjab:—Dist., 272, 275:—Rev. Svy., 7, 272–3, 530; pls. 1, 3, 5, 16, 28.
Gurkhas, of Nepāl, 95, 185, 252, 264, 482:—376; *v.* Goorkhas; Nasri.
Gurwāni merdl. ser., GTS., 2, 12, 17–8, 34, 128, 149, 153, 156, 185, 309 366, 368–9, 393, 412, 422, 496, 516:—Chart, 314 n.5; pls. 3, 4.
Gwalior, CI., 38, 188–90, 376:—Campaign, 1843–4, 498, 522, 528:—Map, 143, 309–10, 315:—Resdt., 188; pls. 1, 3, 4, 5, 16, 28; *v.* Sindhia.
Gwalior & CI. Topo. Svy., 4, 188–90, 214, 363, 428, 491, 513, 518, 522, 525.

HM.'s Troops, Br. Army, 8, 196, 262, 383, 388–9, 418–9, 443, 488, 494, 500, 521, 531, 537, 539.
hadbast, sketch of boundary, 247, 254, 261, 299 n.8, 302; *v. thakbast*.
Haddan, R. G. (d. 1851), arrd. India, 1845/6; GSI., Dec. 1846; 142.
Haider Ali of Mysore (1717–82) [I: 96–8] *DIB.*; xiii.
Haig, F. M. Douglas, Lord (1861–1928), 1st. Earl; 495:—James Felix (1838–1905), HM. 90th Ft., Ens. 1856; bro. to C. T. Haig [500]; 500 n.6.
Hall-stones, 27, 223–4, 491.
Haileybury Coll., Herts., 492 n.3.
Hakluyt Soc., after Richd. Hakluyt (1552?–1616), *DNB.*, 512, 544.
Haldane:—resdt. Debra Dūn 1850, 341 n.2.
Halsted, v. Adm. Edw. Pellew (d. 1873), RN. 1821–70; E. Indies, 1839–42, 196.
Hamilton:—Francis Buchanan (1762–1829), Ben. Med. [I: 315–6, sv. Buchanan), *DNB.*; *DIB.*, 81 n.1, 82:—Sir Robt. North Collie (1802–87), BCS., 6th Bart., AGG. CI., 1854–9; *DNB.*; *DIB.*; 188–9.
Hamirpur, Dist. NWP., 267, 299; pls. 1, 3, 4, 16, 28.
Handbook:—Deptl., 4, 243, 289, 345:—of Drawing, James, 291:—Topo., Deptl., 525.
Handprinting on Maps, 215 n.6, 238–9, 318, 320, 436, 491.
Handwriting, 116–7, 320.
Hanle, Ladākh, 187, 233, 235–6, 425; pls. 1, 3, 5, 6.
Haramukh peak, Kashmir, 16, 872, ft.; 87–9, 225–6, 229, 238, 514.
Hardwār, on Ganges, 16, 81, 207, 374, 423, 461; pls. 1, 28.
Hari Singh (1830–74), asst. rev. survr., 441, 451.
harkaras, messengers [II, 446], 363, 455.
Harper, John (1838–75), civ. asst. Topo., 176 n.2, 422, 428, 431, 527.
Harris:—Chas. Barrett, civ. asst. Rev., 433, 441:—Geo. Aug. (1841/2–74), civ. asst. Trig., 419:—J., civ. asst. Rev., 441:—svys. in Burma, 196:—Wm., inst.-maker, of London [III, 524], 148, 155.
Hasan Abdāl, Punjab, 25 m. NW. from Pindi, 209, 424.
hāth, or cubit [IV, 190 n.6], 302.
haveli, hdqr. lands, 244.
Havelock, Gen. Sir Henry (1795–1857), KCB. & Bart. 1857, *DNB.*; *DIB.*; 374.
havildar, or sgt., 18, 341, 376, 473.
Hawthorne, Gunner, 215 n.6.
Haycock, Alex. Theophilus (b. 1830/1), civ. asst. Trig., 20 n.4, 21 n.2, 405, 419.
Hayward, Lieut. Geo. Jones Whitaker (1839–70), son of Geo. S. Hayward, land-survr. of Headingley, Yorks; Ens. 89th Ft., 1859; tr. to 79th Ft. in India, 1864; ret. 1865; *DIB.*; Mason (91); 507 n.6.
Hayden, Sir Henry Hurbert (1869–1923), Dir., GSI., FGS., Kt., CSI., CIE., FRS., 532.
Hayford, John Fillmore (1868–1925), Coast & Geod. Svy., USA.; *GJ.*, 66, 1925; Victoria Medal, RGS., 1894; 137.
Hazāra Dist., NWF., 213–4, 274, 492:—DC., 187:—Robinson's Svy., 4, 36, 189, 208–10, 227, 317, 363, 387, 524:—Map, 291, 317, 423, 456, 511; pl. 16.
Hazāribāgh, Chota Nāgpur, 13, 142, 311, 324:—*khalāsis*, 31, 362, 454:—Rev. Svy., 244, 497, 525, 528, 535:—Town Svy., 535; pls. 1, 3, 4, 16, 28.
Haze, 16, 23–4, 28, 53, 173, 175, 367, 468.; *v.* Mist.
Headache, 223, 459.
Headley, Lord; Allanson, Rowland Geo. (1855–1935); 5th Baron; Hadji; Presdt. Br. xi, xii Muslim Soc., 505.
Health:—Breakdown, xiii, xiv, 2, 6, 25, 31, 43, 50, 171, 243, 246, 254, 362, 434, 511, 519, 527:—Care of, 365, 367, 369–70, 885–6, 427, 516, 541, 543:—Good, 339; *v.* Sickness.
Hearsey, Hyder Young (1782–1840), adventurer [II, 404–5], 145, 187.
Heat:—of Climate, 278, 330, 449:—Weather, 14, 58–9, 159, 173, 178, 273; *v.* Hot Weather.
Heaviside, Wm. James (1840–1916), RE., 1859–88; GTS., 1865–88; Conolly (94/348); Sandes, II (203); 516.
Hedin, Sven Anders (1865–1925), traveller & geographer; Founder's Medal, RGS., 1898; 96.
Height:—by Barometer, 21, 69, 136, 145, 198, 203, 236:—by boiling point, 69, 203, 236, 449, 507; *v.* Thermometer:—by spirit-levelling, 3, 21, n.5, 48, 76–80, 93, 260, 539:—by trgn., 3, 21, 26, 42, 56, 62, 64–7, 75, 78–80, 137, 212, 230, 236, 238, 286–7:—Comps., 29, 122, 287, 290:—Datum, 93, 139:—Obsns., 81, 448; *v.* Errors.
Heights:—climbed, 3, 5, 65, 203–4, 229, 235:—by Clinometer, 4:—Himālayan, 81–96, 225, 229–30, 232, 234–8, 417, 536:—of hills, 170, 176:—Mapped, 320, 374:—Snow Peaks, 2, 81–94, 136, 145, 202, 221, 229–30, 232, 234–8, 337, 541–2:—Relative, 75:—above Sea-Level, 21, 23, 26, 42, 66–7, 79–80, 91–4, 137:—Spot, 3, 67–9, 213–4, 282, 287, 320, 374, 508:—Topo., 215, 287.
Heliotropes:—Insts., 45, 57, 104, 158, 165–6, 474, 216:—obsns. to, 18, 23–4, 65, 102, 118, 169, 173, 212, 223–4, 226, 287:—poor visibility, 28–9, 41, 55, 59, 117, 221.
Heliotropers, 14, 65, 175, 233, 453–5, 460, 475; *v.* Signallers.
Helio-zinco printing, 254 n.5.
Hellard, Sam. Barnes, Lieut. IN., 18–9–47; 194.
Helmert, Friedrich Robt. (1843–1917), German geodt.; *RAS* (*mn*) 78, 1918 (156–8); 137.
Henderson, John (1795–1836), Ben. Med. 1815–36 [IV, 290]; Crawford's *Roll*; ix, 240.
Herbert, James Dowling (1791–1833), Ben. Inf. [III, 457–8]; Hodson, II (434), vi, 5, 35, 81, 86, 92, 134, 136, 157, 200, 346, 376, 405, 511:—Svy., Pamphlet, 297.
Herdsmen, 39, 52, 479.

Hernia, or rupture, 405, 464.
Herschel, Sir John Fredk. Wm. (1792–1871), 1st Bart., *RAS* (*mn*) 32 (122), & his father, Sir Wm. (1782–1822), both FRS., *DNB.*; *RS Procs.*, XX, 1872 (xvi); 880, 508.
Heyne, Benjamin (1770–1819), Mad. Med.; [II, 405–6], botanist, vi.
Heynham:—Dep. Collr., Calcutta, 183:—Wm. (b. 1821), civ. asst. Rev., 411 n.2, 433, 441.
Hexagon of trgn., 29, 89, 41, 46, 102, 122.
High-water level, 67, 69–78; v. Tides.
Hijli, Midnapore, 25, 65, 103, 463 [IV, 484; pl. 3, Hijellee].
Hill, Thos. (c. 1786–1846) [III, 385]; vii, x.
Hill:—Dists., Himālayan, 34, 36:—Journeys, 371, 406:—Men, *pahāris*, 87, 87, 430, 479:—Sacred, 2, 35–6, 201, 220, 222, 470, 472:—Series, 2nd., GTS., v. Parties:—Stations: GTS., 21, 26, 30, 36, 45–7, 63, 112, 138, 404, 410, Health Resorts 48, 369:—Topo. Svy., 173, 202, 204, 207–8, 217, 287, 289.
Hill:—Drawing & Shading, 167 n.4, 171–2, 176, 186, 192, 231, 290–1, 311, 318, 320, 330–1, 353, 489:—Sketching, 89, 197–8, 208, 210, 216–7, 219, 225–9, 235–9, 283, 288, 385, 423–4, 428, 493.
Hills:—Isolated Tops, 29, 44–5, 170, 216, 468:—Wooded, or jungle covered, 287, 378:—Assam, 31–2, 362, 468.
Hilly Country, 75, 97, 151:—Chota Nāgpur, 184:—Central India, 189:—East Coast, 167–8:—Gujarāt, 60:—Nilgiri, 179–80:—Orissa, 4, 27–29, 176, 362, 378, 421, 462–3, 527:—Punjab, 149, 200–2, 213–4, 218, 270–3, 375:—Kāthiāwār, 58:—NWF., 540:—Rājputāna, 2, 88, 50:—6. India, 8, 283:—Sind, 42–6:—under Rev. Svy., 241, 243, 265, 275, 284, 301.
Himālaya Mts., xvi, 38:—Bdy. Missions, 186–8, 536, 544:—Gt. Arc objective, xiii, 137:—Foot-hills, 2, 34, 37, 75, 81, 105, 200–2, 230, 496:—High, 426, 467, 490:—Maps, 30–1, 318–9, 330–1:—Name, 188:—Orography, 520:—Scientific Research, 527:—Topo. Svy. NW. Him. Party, xiv, 1–5, 9, 34–6, 136, 200–8, 221, 285, 318–9, 361, 363, 416–7, 421–3, 426, 428, 496, 505, 509, 516–7:—Trans., 380:—Trgn., 65, 83, 91, 97, 288, 337, 361, 379, 416. v. Heights; Passes; Peaks; Sikkim.
Himālaya Range:—t-page, 3, 5, 81–2, 85–7, 92, 95, 135–6, 144–5, 202–5, 220, 222, 226, 228, 230, 235–7, 239, 283, 398, 429, 467, 504–5, 517, 535, 542:—Highest in World xv, 81, 83, 89, 91–2, 203, 231, 340, 423:—Upper, 235–6, 286, 380, 416, 426.
Himālayan:—Geography, 136, 144, 146, 185, 337, 531:—Travels, 145–7; v. Attraction, Deflection; Explorers; Passes; Peaks; Snow.
Himalayan Journal, Calcutta annual, 188.
Hindu:—College, Calcutta, 521:—Customs, 459:—Kush, range, ix, 146, 227, 235, 538:—People, 459, 472:—Shrines, 470.
Hindustān-Tibet road, 518.
Hindustāni:—Language, 236, 488, 526–7:—People, 238, 452, 454.
Hints to Travellers, RGS.; 1st. edn. 1854; 9th, 1906; 540.
Hirst, Lt.-Col. Fredk. Christian (1874–1938); IEC. [I: 226 n.3], s of I., 1900–1929; 182, 186 n.4.
Hissār, Punjab, 7, 50, 265, 511:—Rev. Svy., 270, 508; pls. 1, 5, 16, 28.
Historical Notes, 129, 264, 341, 345–6, 510.
Historical Research, Army Society of; 493, 499.
Ho, or Kol, tribesmen, Chota Nāgpur, 176.
Hobday, Alex., civ. survr., Burma, 1848–60; 194, 196, 244 n.2, 425.
Hobson-Jobson, by Yule & Burnell, 1886, xxvi, 540.
Hodges, Alex. (1800–41), Ben. Inf. [III, 458–9], 248–9:—Nathaniel (b. 1805), civ. asst. Rev., 437 n.6, 441.
Hodgson:—Brian Houghton (1800–94), BCS., FRS., *DNB.*; *DIB.*; Resdt. in Nepāl, 1833–43; *RS Procs.*, LX (xxiii–vi), 1894, 85 n.4, 88, 94–5, 318, 502:—M Gen. John Anthony (1777–1848), Ben. Inf. [III, 459–61]; SG. 1821–3, 1826–9; vii, viii, 35, 81, 92, 134, 136, 157, 200, 297, 346–7, 405, 414.
Hodson:—Wm. Stephen Raikes (1821–58), Ben. Inf. & Corps of Guides; raised Hodson's Horse, 209 n.6, 535:—Maj. Vernon C. P., Indian Army (1884–1963), [I: x; II, xvii], xvi, xxvi.
Holdich, Col. Sir Thos. Hungerford (1843–1929), RE., s of I., 1868–99 [IV, xvii, 484]; KCIE., 1897, KCMG, 1902; PRGS., 1916–8; Gold medal 1887; *Ency Brit.*, *DIB.*; Conolly (n.1/1136) 489 n.9, 538.
Holkar, Mahārāja of Indore, 38, 190, 343.; v. Indore.
Hooghly Dist., Bengal:—Maps, 314:—Rev. Svy., 6, 241–2, 246–8, 295, 299, 303–4, 434; pls. 1, 16, 28.
Hooghly:—RIVER, 15, 24–5, 66, 69–70, 80, 108, 140, 182–3, 248–40, 357, 416, 519:—Map, 15, 183, 250, 372 n.2, 519:—trgn., 463.
Hooker, Sir Joseph Dalton (1817–1911), botanist; India 1847–51; CB., 1869, KCSI., 1877; GCSI., 1879; OM., 1907; FRS., LS.; *DIB.*; Burkill, III (687), IV (338–41); *Who Was Who*; 183, 186, 312, 536.
Hopkinson, Gen. Henry (1820–99), Ben. Inf. & RC., 1837–89, Asst. Comnr., Tenasserim, 1850; capture of Martaban, 1852–3; Comnr. Arakan; Assam; & AGG., NEF.; CSI., 1874; 194.
Hoppner, Edw. Wm. (b. 1812–3), civ. asst, Rev., 259, 260 n.1, 261, 263, 349, 352 n.6, 353, 359, 433, 435, 441, 505.
Horizon:—Natural, 65, 71:—Artificial, 131, 208.
Horse:—allce., 374, 405, 450:—hair, 223:—men, or *sowars*, 179, 219, 474–5, 485–6, 507:—fall, 446, 488:—riding, 542.
Horses & ponies, 44, 59, 73, 341, 364, 369, 371–3, 414, 430, 468, 500, 507, 528.
Hörst, Henry (1834–77), civ. asst. Topo., 190, 211–3, 424, 428, 431.
Hoshiārpur, Punjab, 2, 34–5, 162, 200–2, 474, 496, 517:—Rev. Svy., 7, 270–3; pls. 1, 3, 5, 16, 28.
Hospital, 16, 527.
Hot weather season, 201, 257, 267, 328, 333, 366, 526, 530, 534, 544; v. Heat.
Hotels, 532, 543.
Housden, Geo. P. (b. 1830/1), civ. asst. Rev., 269 n.5, 275, 433, 436.
Houses:—European, 14, 224, 249–50, 369–70, 508, 524:—village, 192, 491.
Howard:—Geo. Robt., 28–8, 170–1, 172 n.5, 174, 414, 422, 431 & Robt., his elder bro. (d. before Nov. 1862), both civ. asst. Topo., [IV, 385], vii, 167–70, 363, 421–2, 431, 463–4, 500:—R., civ. asst. Rev., Punjab, 269 n.5, 441.
Howrah, Calcutta, 181–3, 250:—Rlwy. Stn., 374.
Hudson, Christopher K., asst., comnr. Assam [IV, 399, 484], 253.
Hügel, Carl Alex. Anselm, Baron von (1794/5–1870), German Naturalist, *Ency Brit.*; Burkill, II (58) [IV, 450, 484]; ix, xi, 67.
Hulka, rev. block boundary, 251, 254.
Hullmandel, Chas. Joseph (1789–1850), German Lithgr. [IV, 469 n.1, 329 n.4.
Humboldt, Freidrich Heinrich Alex., Baron von (1769–1859), German Naturalist, [III, 525; IV, 112], yr. bro. to Wm.; *Ency Brit.*; *JRGS.*, 29, 1859 (cii–xii); 144, 146, 527.
Humidity, 140, 163, 171, 463.
Hunter:—Dr. Robt. (1823–97), Madras miasm., 143:—Dr. James de Graaff (b. 1880), s of I., 1907–34; DSc., Camb., 1920; FRS., CIE., Geodt.; xvi, 65 n.7, 66, 91, 93, 96, 137:—Sir Wm. Wilson (1840–1900), BCS., CSI., CIE. [I: 337]. *DNB.*; *DIB.*, *Who Was Who*; 382.
Hunting, or *shikār*, 88, 264, 467, 479, 491 n.1, 504; v. shooting.
Hunza & Nagar, Karakoram, 237, 240, 481, 515.
Hurilaong merdl. ser., GTS., 13, 18, 83–4, 90 n.4, 91, 101, 115, 126, 155, 185, 410, 415, 501; pls. 3, 4:—Fd. Party, 52, 337, 361.
Husain Baksh, traverser, 260, 264, 494.
Huts:—village, 490:—in field, 21, 222, 457.
Hutton, Dr. Chas. (1737–1823), mathn. [I: 248], FRS., *DNB.*; 297:—Log. Tables, 123–4, 297 n.6.
Hyam Essaji, asst. survr. [III, 393; IV, 399], 450.
Hyderābād, Nizām's Dominions, vii, xiii, xiv, 10, 172, 478:—Ceded Dist., or Berār, 178, 404, 414, 417, 444:—Resdt., 177–9, 268:—Topo. Svy., 1, 3, 34, 142, 167, 172, 177–9, 282, 285, 290, 363, 372, 384, 496, 517–8:—Suspended, 178, 363, 384, 392, 396, 416, 426, 455:—461, 493, 495:—Resumed, 206, 268, 421, 426, 428, 517:—Fd. Party, xiv, 285, 338, 371, 421–2, 428, 427:—Civ. Asst., 169, 172, 176–9, 424, 428–9; pl. 28; v. Berār; Circārs.
Hyderābād, Sind, 42, 277, 371–2, 375, 533; pls. 1, 2, 3, 28.
Hydrographer, HEIC., 126, 309.

Ibex, 88.
Ibi Gamin, Kāmet, 86–7, 147, 528.
Ibn Haukal, (c. 950 A.D.), Arab geographer [I: pl. 4], 240.
Ice:—Himālayan, 236, 425, 508:—House, 504.
Idleness, 412, 449–50.
Ignatio, Colin Francis, civ. asst. Topo., son of Christian Andreas Madras dmn. [III, 316, 385]; 421, 431.
Ilchi, Khotān, 237–8, 507, 528.
Images, Hindu, 382, 410, 535.
Ill-health, or sickness, 13–8, 25–8, 30–1, 41, 44, 44–6, 50, 54–5, 59, 167, 197, 212, 233, 246, 256, 259–61, 278, 340, 348, 353, 362, 374, 386, 409–10, 415–7, 435, 438, 456–68, 477, 489, 495, 498, 504–5, 511, 518, 526, 532, 534, 544; v. Health.
Impertinence, 304, 412.
Imprisonment, 471, 476.
Indentures, 403, 418 n.1, 424, 430 n.4, 437, 449–50.
Indents on England, 124, 157.
India:—Council, 331:—House, London 127–8, 212, 309–10, 312, 317, 324, 326, 329, 344:—Office, from 1860, 141, 239, 379, 501, 512–3, 518–9, 540:—Records, xvi.
Indian, or "native":—Educated staff, 354, 404–5, 408, 487, 446–50, 522:—Instructors, 191, 449–50:—Land Measurers, 8, 244, 273, 279, 300–3, 446, 501; v. *amins*:—SURVRS.:—Pupils, 192, 344, 449–10, 517:—Rev. Svys., 184, 242, 246, 249, 260, 265–6 268, 275 n.2, 276–7, 304, 365, 434, 441, 446, 449–52:—Topo., 94, 172, 178–9, 190, 203, 215, 218, 249, 344, 416, 446–50, 539; v. Doctors; Dmn.; Explorers; Followers; Levellers; *mutrudis*; Planetablers.
Indian:—Empire, Companion of, 448:—Navy, 70, 274.
Indigo factories & planters, 83, 311, 418, 440, 501; v. Blue.
Indore State, 55, 188, 392, 500; pls. 1, 3, 16, 28; v. Holkar; Mhow.
Indus R.:—1–4, 7, 37, 41–3, 46–9, 53, 59–60, 78, 92, 100, 109, 192, 209–10, 214–8, 220, 274–5, 317, 337, 364, 475, 532, 534:—Floods, 482:—Flotilla, 1835–62: v. *Imp. Gaz.*, XIII (363), 77, 372, 420, 513:—Maps, 317:—Mouths, 59:—Upper, 87–8, 187, 226–7, 229–30, 232–3, 235–7, 286, 481–5, 531:—Valley, 3, 35, 80, 105, 146, 159–60, 467; v. Boats; Gt. Indus ser., trans-Indus.
Inexperience, 4–5, 26, 146, 167, 177–8, 192, 195–6, 198, 209, 241, 266, 281, 363, 384–6, 387, 390, 409, 423, 426, 449–50, 492–3, 495, 497, 500, 524–5, 528, 538.
Infantry:—Bombay, 56, 398:—British, 389:—Escort, 188, 376:—Officers, 5, 10, 379–80, 390:—Regts., 460, 464.
Information, geogl. and pol., 217, 507, 511.
Ingram, Capt. James Scott (b. Bareilly, 1829), Ben. Inf., & FWD., 1849–66; 208 n.6, 423 n.2, 524 n.4.
Inhabitants:—friendly, 40, 192, 231, 426, 478, 489, 506, 511, 516–7:—Scarce, 27, 216, 252:—Suspicious, 231, 468, 527:—Unfriendly, 86, 89, 117, 222, 229, 489.
Ink:—writing, 122:—litho., 329, 332–3.
Insects, destructive, 105, 250, 256, 288 n.5, 326.
Inspection:—of Fd. Parties, t-page, 10, 155, 170, 176, 427, 534:—Planetablers, 218, 337, 447:—Rev. Svys., 261, 488, 525:—Trgn. 234, 237–8, 515.; v. Check; *partāl*, SG.
Instructions:—Medical, 458–9:—PROF., 10:—Levelling, 76:—Rev. Svy., 297:—Topo., 112 n.2, 171, 195, 214, 261, 289, 385, 519:—Trig., 97–8, 102, 104–5, 115–7, 122, 150, 179, 282, 286, 342.
Instructions, printed, 390, 542:—*Topo.*, 195, 211, 213, 282, 284, 289, 338, 525:—*Trig.*, 98 n.5, 179, 192, 282 n.2, 286, 338.
Instrument Makers, xiii; v. Mathematical.
Instruments:—Astr. 46, 131, 167, 534:—Box of, Drawing instn., 516, 531:—Care & Adjustment, 122, 137–8, 346, 383, 393, 409, 435, 532:—Cleaning, 131, 163, 168:—Cost, 159:—Custody, 158, 162–5, 350, 361, 372, 376–8:—Damage, or accident, 162–3, 346, 523:—Depot., DDn., 502:—Explorers', 146:—GTS., 10, 21, 34, 63, 66, 97, 131, 162–3, 351, 478, 533, 534:—Indents & Supply, 145, 157, 165–6, 298–9, 350:—Levelling, 539–40:—Loss or Theft, 77, 346, 377, 483:—Ordn. Svy., 502:—Portability, 149, 151, 533:—Repairs, 145, 162–4, 299, 337, 350, 357–8, 379:—Rev. Svy., 8, 165, 266, 293, 298–9, 350:—Scientific, & Inspector at IO., 10, 145, 357, 379, 533:—Shortage, 193, 266:—Topo. Svy., 168, 188, 208–9, 286:—Transport, 158, 221–2, 363, 371, 455:—Un-

servicemahls, 162, 163, 164, 166 :—Use, 163, 168, 284, 544 ; *v.* Guard ; Isolation ; Pillars ; Platforms ; Workshop.
Insubordination, 394–5, 415, 449, 484, 496.
Insurrection, 35, 162, 474, 484.
Interior detail, Rev, Svy., 218, 267, 278, 295, 302.
Intermixed lands, 243, 245, 251, 254, 267, 300–1 ; *v. parganas.*
Interpreters, 32, 236, 448, 526.
Intersection of points and detail, 17–8, 85–6, 90, 114, 116, 184, 215–6, 219, 221, 226.
Intervisibily, 1, 52–3.
Iron :—Bars, 158–9 :—Cast, 152 :—Ore, 142–3, 190, 526 :—Search for, 324 :—Wrought, 160–1, 223.
Irrawaddy R., Burma, vii, 194–7.
Irrigation :—Dept., Punjab, 68 :—Sind, 193 :—Projects, 3, 68, 258–9, 261–2 :—Lack of, 274 :—Svys., 8, 74, 267, 309, 505, 509 ; *v.* Canals.
Ishāpore, on Hooghly R., 256, 537.
Islāmābād, or Anantnāg, Kashmir, 224–5, 228, 490, 505 ; pls. 1, 6, 13, 28.
Islands, 57, 256 :—of rivers, 262.
Isolation of :—Fd. Parties, 122, 370, 382, 386, 390, 392 :—Insts. for stability, 12, 16, 24, 96, 99, 105–10, 112–4, 198 ; *v.* Pillars ; Platforms.
Isostasy, 137, 521.
Ivey, Wm. (1820/1–83), civ. asst. Rev., 113 n.5, 246, 250 n.6, 304, 441.

Izzat Ullah, Saiyad Mir [II, 431], explorer, 220.
Jackson, M Gen. Chas. Forbes (1809–70), b. Jamaica ; Bo. Cav. 1826–58 ; comdg. Nimbhera Force, Rājputāna, 1857, 191 :—ABC., civ. asst. Rev., cis-Sutlej, 1847 ; 270 n.5.
Jacob, Brig.-Gen. John (1812–58), Bo. Art. [IV, 448], CB., 1850 ; Comnr. NW. Sind, 1856 ; *DNB.* ; *DIB.* ; x, 45–6, 78, 194, 278–9 :—Capt. Wm. Stephen (1813–62), Bo. Engrs. [IV, 448–9], *DNB.* ; *DIB.* ; Conolly (89/106) ; FRAS. ; GTS., 1833–43 ; x, 66–7, 72, 346, 391, 523, 534.
Jacobābād, Upper Sind, 54, 62, 78, 112, 156, 219, 278, 391, 523, 534, 540 ; pls. 1, 5, 38.
jagir, or rent-free lands, 8, 222, 264–5, 267, 269–70, 376–7, 292, 494.
Jains, Hindu sect., 462–3 :—Temples, 517.
Jaintia Hills, Assam, 488 ; *v.* Khāsi. :—*parganas*, Sylhet, ; x, 32, 536 ; pls. 1, 16, 28.
Jaipur, Rājputāna, 50 :—Maharāja, 264 ; pls. 1, 3, 5, 16, 28.
Jalaun, Bundelkhand, 267, 529 ; pls. 1, 3, 5, 16, 28.
Jalpaiguri, N. Bengal, 337–8, 476, 484, 496 ; pls. 1, 28.
James :—Lt.-Gen. Sir Henry (1803–77), RE., KCB. 1860 ; DG., OS., 1854–75, *DNB.* ; Conolly (24/604) ; 339, 502 :—John Owen Nix (1829–1900), civ. asst. Trig., Topo., & CD., 4, 15 n.1, 20 n.4, 37 n.3, 42, 84, 211–2, 291, 331, 349, 353, 359, 407, 414, 419, 424, 426–7, 431, 525 :—Joseph Arthur (1827–59 ?), civ. asst. Topo., 210–1, 403, 414, 423–4, 431 :—Wm. Nix (1805–44), Civ. Asst., Rev. & Trig. [IV, 384], 2, 12, 336, 361, 402, 414, 419 :—Wm. Richd. Nix (1827–76), civ. asst. Trig., 12 n.4, 22 n.4, 24–5, 36–7, 42–3, 50 n.3, 86, 168, 215–6, 403, 409, 414, 419, 427, 475.
Jammu, 1–3, 5, 34–6, 50, 157, 208, 220, 225, 230–2, 286, 389, 472, 475, 480, 508 :—Border with Punjab, 119, 187, 208, 210, 388, 472, 506, 511–2, 514 :—Bdy. Svy., 210, 375, 406, 524 :—Foothills, 89, 488–9 :—Maharāja's Territories, 479–80 :—Map, 238, 480 ; pls. 1, 3, 5, 6, 13, 16, 28 ; *v.* Kashmir :—Maharaja, J. & K.
Jamuna R., Bengal, 255, 294.
Jardine & Skinner, Calcutta, commercial firm, 437.
Jashpur State, Orissa, 169–70, 173, 175.
Jaswan Dūn, Sirmūr, 35, 157, 474.
Jhaunsar Bawār, Chakrāta, NW. of Dehra Dūn [IV, pl. 17], 200, 206, 538.
Java, East Indies, 120, 536.
Jech, or Chuj, *doāb*, Punjab, 7, 52, 273, 436, 508, 530 ; pl. 16.
jemadar, head *khalāsi* of svy. unit, 16, 333, 365, 377, 454–5.
Jenkins, Francis (1793–1866) ; Ben. Inf. [IV, 449], AGG. NE. Frontier, vii, ix, 29, 253, 311, 461.
Jervis, Geo. Ritso (1794–1851), Bo. Engrs. [II, 409], Conolly (104/51), 191 n.8, 244–50 :—Thos. Best (1796–1857) ; Bo. Engrs. [IV, 449–51], Conolly (104/58), x, 322, 450.
Jessore Dist., E. Bengal, Rev. Svy., 6, 243, 253, 255–6, 499 ; pls. 1, 3, 16, 28.
Jeypore State, Vizagapatam, 167 n.4, 490, 527 ; pls. 1, 3, 28.
Jhang Dist., Punjab, 273–4, 442, 492 ; pls. 1, 5, 16, 28.
Jhānsi, CI. :—1857 tragedy, 1, 267, 364, 396, 435, 483, 494 :—Rev. Svy., 1, 267, 435, 494, 538 ; pls. 1, 4, 5, 16, 28.
Jhelum, Punjab, 3–4, 52, 210–2, 239, 274, 316–7, 337, 490–1, 539 :—River, 4, 7, 37, 51–2, 119, 210, 214, 224, 226, 228–31 (Vedusta R.) 273–4, 317, 375, 488, 490, 493, 514, 524, 530 :—Valley, 187, 224 ; *v.* Rāwalpindi Svy.
Jodhpur State, Rājputāna, 310, 316, 371, 518 ; pls. 1, 3, 5, 28.
Jogi-Tila ser., GTS., 3, 46–9, 51–3, 65, 75, 77, 102, 111, 132, 150, 159, 273, 361, 370, 405, 415, 426, 448, 482–4, 490, 493, 534, 539 :—TS., 37, 51–2, 132 ; pls. 3, 5, 6.
Johnson, E., Ben. Marine ? Burma 196 :—Thos. Geo. (1856–1901), Ben. Inf. & Burma Comn. 505, 508 n.5.
Johnston, Alex. Keith (1804–71), cartographer of Edinburgh, *Ency Brit.* ; *DNB.* ; 146–7.
Jones :—Sir Wm. (1748–94), Judge, Ft. Wm. [I, 342] ; FRS. *DNB.* ; *DIB.*, 321–2 :—Maj. Wm. (1812–71), Ben. Engrs., Conolly (88/162) [IV, 451], 11, 258, 318 :—Wm., optician & inst. maker, [III, 526 ; IV, 485] 208 :—Sgt. w. Sind Rev. Svy., 444.
Jopp, Maj. John (1792–1861), Bo. Engrs. [III, 464] ; Conolly (104/52) ; 191, 276.
Joseph, Chas. (1802–59), dmn. [IV, 485], 315, 353–4, 359.
Journals :—Survrs'., 346 :—Travellers', 220.
Journeys to & from fd., 369–70, 454.
Jubbulpore, CF., 6 :—Rev. Svy., 262, 268, 364, 436, 486, 492, 505, 519, 528, 538 ; pls. 1, 3, 4, 28.
Judges :—Adv. Gen., 339 :—Bengal & Bihār, 245, 257, 322 :—Sessions, 504.
Jullundur, Dist., Punjab, 3, 7, 34, 50, 200 :—*doāb*, 7, 34, 200, 269–71, 308, 337, 413 :—Rev. Svy., 200, 270–1, 273, 316, 500 ; *v.* trans-Sutlej ; pls. 1, 3, 5, 6, 16, 28.
Jumna R., 11, 137, 201, 207, 267, 269, 316, 496 :—Canals, 531 :—through plains, 64, 104 :—Upper, 207, 393, 423, 517.
Junction between svys., 253, 274–5, 298.
Jungle, 510 :—Burning, 26 :—clearing, 17, 101, 174, 197, 406, 476–7 :—Mapping & Svy., 246, 258, 262, 278, 282 :—OBSTRUCTION :—to movement, t-page, 52, 249, 255–6, 374, 412 :—svy., 29, 38–9, 41, 77, 100, 174, 196, 198, 218, 246, 253, 255, 259, 266, 526 :—Unhealthy, xiii, 55, 246, 283, 386, 457–62, 464–7, 496, 519 ; *v.* Bamboo ; Hills.
Jungle Mahāls, Midnapore & Mānbhūm [IV, 60 n.1, 485], 246 ; pl. 16.
Jupiter's satellites, 281.

K 2, Karakoram Pk., 28,250 ft., 3, 5, 88–90, 136, 225–6, 229–30, 232, 235, 380, 489, 493, 506, 514 ; pls. 1, 3, 5, 6.
Kābul, Afghānistān, v, 85, 316, 448, 481 :—River, 65 n.5, 215 ; pls. 1, 28.
Kafirstān, 481, 511 [IV, pl. 16].
Kāgān ; Valley, Hazāra, 208–9, 227–8, 231, 236, 493, 511, 515, 538 :—Peaks, 230 ; pl. 6.
Kailas Pk., N. of Mānasarowar Lake, 22,028 ft., 187, 532.
Kaimur Hills, Mirzāpur, 12, 457, 459, 498 ; pls. 1, 28, Khymore.
Kaithal, Punjab, 268–70, 297, 435 ; pls. 1, 40 m. W. of Karnāl, 5.
Kālābāgh, on Indus, 44, 46–7, 49, 78, 110, 119, 153, 210, 212, 217, 274, 337, 540 ; pls. 1, 3, 5, 28.
Kaliāna, [IV, pl. 4], Gt. Arc, nr. Muzaffarnagar, 124–5, 133–7 ; pl. 3.
Kaliānpur [IV, pl. 4], Gt. Arc, nr. Sironj, 98, 113, 124–5, 130, 132–4, 136, 469, 533. :—Obsy. 113 pls. 1, 3, 5.
Kālka, Punjab, 25 m. S. of Simla, 35, 206, 474.
Kālpi, on Jumna, 267, 438 ; pls. 1 (Calpee), 28.
Kāmet Peak, 25,477 ft., Kumaun, 86–7, 147, 482, 509, 528 ; pl. 3.
Kanāwar, Upper Sutlej, 202, 207–8, 517.
Kandahār, Afghānistān [III, 451–3] 217, 316, 511 ; pls. 1, 5, 28.
Kangchenjunga, Sikkim, 28,146 ft., 82–3, 85–6, 91–2, 186, 337, 528–9 ; pls. 1, 3, 28.
Kāngra, Punjab Himālaya, 2, 7, 34, 50, 146, 200–2, 205 :—Rev. Svy., 270–2, 301, 316, 435, 510 :—Topo. Svy., 413, 416, 426, 496, 516, 544 ; pls. 3, 5, 6, 16.
Kānungos, rev., officials, 292.
Kapūrtala, Maharāja of, 502 n.12 ; pls. 1, 5.
Karāchi, Sind, xiv, 2, 3, 35, 37, 41–6, 48, 50, 60, 67, 74–80, 98, 130, 146, 151, 158, 160, 193–4, 358, 362, 371, 375, 416, 438, 470, 483, 509–10, 528, 534 :—Ballard Pier, 74 :—Bath Id., 130 :—Harbour, 74, 194, 277, 532 :—Latitude obsns., 130, 534 :—Rev. Svy., 277–9 :—Rlwys., 375, 495, 510 :—Science Instn., 492 :—Tidal Stn. & Sea-level, 3, 67, 72, 74–5, 80, 91 :—Town Svy., 277, 511 :—pls. 1 (Kurrachee), 3, 5, 23 ; *v.* Base-line ; GTS. ; Gt. Longl. ; Obsy.
Karakoram (= black stone) :—Pass, 146–7, 187, 232, 236–8, 506–7, 528, 536 :—Peaks, 83, 225–6, 229, 380 :—Range, 5, 87–90, 146, 187, 232, 235–7, 429, 489, 493, 541 ; pl. 6 ; *v.* K 2.
Karara merdl. ser., GTS., 1, 11–2, 16, 21–2, 34, 84, 101, 103, 105, 119, 132, 134, 148, 155–6, 185, 309, 336, 361, 368, 390, 393, 415–6, 496, 522, 530, 541 :—Map, 184, 496 ; pls. 3, 4.
Karen survrs., Burma, 5, 198, 425, 447.
Kargil, Ladākh, 233, 512, 515 ; pl. 13.
Kasauli, Punjab, 202, 496, 513 ; pls. 1, 5, 6.
Kāshgar, Central Asia [IV, pl. 16], 146, 240, 448, 508, 527–8.
Kashmir, 220, 480 :—Frontiers, 4–5, 86, 187, 423 :—Heights, 66, 83–90 :—Inhabitants, 221, 236, 240 :—Maharāja, J. & K. 36, 220–2, 224, 226, 228, 230–3, 236–9, 418, 472, 475–6, 480–1, 485, 508 ; *v.* Gulāb Singh : Ranbir Singh :—Officials, 221, 228, 236, 480, 514–5 :—Photographs, 141, 331 :—Troops, 226, 232, 515 :—Visits by European travellers, 76, 87, 146–7, 220, 240 :—Visitors, 480 :—Valley, 5, 220, 223–8, 230–1, 238, 286, 388, 480, 513 ; *v.* Maps ; Panorama ; Passes ; Peaks ; Route Book ; Srinagar.
Kashmir Party, 5, 48, 141–2, 208, 221, 226–7, 236, 291, 331, 361, 363, 370, 380, 485 :—MIL. OFFR'S. : Trgn., 380, 399, 490, 493, 513–6, 537–8 :—Topo., 388–9, 399–90, 423, 488–9, 505, 511–3, 518 :—CIV. ASSTS., Trgn., 404–5, 417–8, 405–8 :—Topo., 213, 403, 424–5, 428, 464–5 :—FOLLOWERS, 226, 454, 461.
Kashmir Svy. : Topo., 3–5, 9, 69, 89–90, 220, 226–7, 229–38, 425 :—Trgn., GTS., 1, 3, 5, 37, 87–9, 149, 157, 230–7, 286, 485, 490, 493, 505–6, 514–6, 538 :—Secondary, 226, 228, 233–4, 425, 506.
Kashmiri Compass, 302.
Kāthiāwār, or Saurāshtra, v, 470, 500 :—Coast, 58–9, 74 :—Map, 191 :—Topo. Svy., 57 :—Trgn., GTS., 3, 34, 54, 57–60, 74, 118, 500, 518, 523 ; pls. 1, 3, 28.
Kātmandu, Nepāl, 85, 94–5, 147, 528 ; pls. 1, 3, 4, 28.
Kavanagh :—Sgt. John, PWD., Canals :—John Chas. (1823/4–68), civ. asst. Rev., 509 :—Thos. Henry (1821–82), Asst. Comnr., Punjab, 1852 ; Vo. Lucknow, 1857, all 509.
Keane, J., civ. asst. Rev., 270 n.5, 441.
Kedārnāth, Great Himālaya, Garhwāl, 22,770 ft. ; 81.
Kedgree, Hooghly R. [1 ; pl. 14, Cudjeree], 25, 71, 140, 463.
Keelan, Henry Elliott Thos. (1843–95), civ. asst. Trig., 234, 416, 419, 509–10 :—Luke, Condr. Ordn. [IV, 384], 509–10.
Kelly, Predk. Wm. (b. 1833), civ. asst. Rev., 267 n.6, 436, 441 :—W. M., civ. asst. Rev., Bo. ; 445.
Kelso, John (1803/4–1855 ?), civ. asst. Rev., 242, 253, 312, 434, 441
Kendall, Dr. Bernard, Ben. Med., Crawford ; 176.
Keonjhar, Orissa 27, 168 n.2, 170, 172, 175, 364 ; pls. 1, 3, 7 n. 28.
Kew Obsy., London, 502, 516, 540.
Khairpur State, Sind, 191, 279 ; pls. 1, 28 (Khyrpoor).
khalāsis, svy. followers :—GTS., 16, 31, 50, 59, 84, 158, 162, 356, 369, 378, 412, 454 :—Topo., 208, 213, 282, 429, 467, 485 :—Rev. Svys., 244, 266, 284, 322, 365, 449, 452–6, 486 :—Up-country, 256 ; *v.* Followers ; Hazāribāgh ; Lascars.
Khāndesh, Bo. Deccan, 275 :—Rev. Svy., 494, 497 :—Topo. Svy., 1872–80, 428, 430–2 ; pls. 1, 28.
Khāpūsura merdl. ser., Bombay, 3, 38, 51, 54–6, 60–2, 99, 102, 156, 523 ; pl. 8.

Khāsi & Jaintia Hills, Assam, xiv, 2, 31–2, 145, 183, 253, 312, 362, 544 :—Geology, 488 :—People, 32, 253, 468 :—Supt., 253 :—Topo. Svy., 1803–75, 447, 489, 513, 519 ; pls. 1 (Cossyah), 16, 28.
khasrah, fd. to fd. rev. meast., 6, 165, 241–2, 244–8, 251–3, 263–4, 268–71, 293, 300–2, 450–1 :—Bengal, LR., 294–5, 299, 304, 365 :—Punjab, 271, 302 :—control, 247, 253, 293, 299–300, 350 :—comparison with prof. svy., 246, 263–4, 271, 278, 293, 304, 451 :—Maps, 251, 263, 293 :—est., 365, 455 ; v. *amins* ; Indian measures ; *shajrah*.
Khattak, hills & tribesmen, NWF., 47, 215–6, 377 ; pl. 9.
Khōnd :—Hills [IV, pl. 15] ; Agency, 170, 174–7, 368, 464 :—tribesmen, 27, 176, 517, 527.
Khotān, Central Asia, 5, 236–8, 507 ; v. Ilchi.
Khyber Pass [IV, pl. 16], 146, 216–7, 317, 475, 524.
Kidarkānta, Tehri Garhwāl, 45 m. N. of Mussoorie, 12,509 ft. [III, pl. 5] xi, 81, 207.
Kidderpore, Calcutta, 69–70, 504 :—Bench-mark, 183 :—Docks, 70–1 :—Svy., 181, 183 :—Tide-gauge, 70, 80, 88.
Killed :—in mil. action, 501 :—otherwise, 219, 228, 267, 364, 396, 483.
King :—John Geo. (b. 1816), 168–9, 171–2, 174, 176 n.6, 431, 464 :—W., his son, 422, 428, 431, both civ. asst. Topo.
Kirkpatrick, Wm. (1754–1812), Ben. Inf. [I : 344–5, II, 468], 92, 531.
Kirpa Ram, civ. asst. Rev., 441, 451.
Kirwan, David (b. 1814/5), civ. asst. Trig. [IV, 384], 11 n.3, 22 n.2, 369, 409, 419.
Kishen Singh, explorer, AK. (c. 1841/3–1921) ; *GJ.* 62, 1923 (429–40) ; 448.
Kishanganga R., Kashmir, 226–7, 229–30, 232–5, 239, 493, 506 ; pl. 6.
Kishtwār, Kashmir, 205, 220, 227, 518, 536 ; pl. 6.
Kistna Dist., Madras, 280, 495 :—Rev. Svy., 521 :—River, 29, 283, 386 ; pl. 28.
Knox, Geo. (1834–1917) ; arrd. India 1854 ; Asst. Engr., Punjab, May 1854 ; uncov., civ. Asst. Comnr., June 1856 DC. ; Kulu, 1858 ; ret. 1890 ; 528.
Kohāt, NWF., 4, 47, 146, 210, 215–6, 218, 337, 498–9, 539 :—Dist., 218–9, 317, 539 :—Pass, 217, 475 ; pls. 1, 5, 28.
Kohistān, or *hill country*, 214, 274, 318, 413.
Konkan, W. Coast :—NORTH, 59 :—Singhi ser., GTS., 8, 54–5, 57, 61, 467–8, 523 :—Topo. Svy., 191 :—SOUTH, 3, 54 :—merdl. ser. GTS., 3, 54–5, 62, 72, 122, 392, 450, 523, 541 ; pls. 1, 3, 28.
Kosi R., Nepāl & Bihār, 17, 19, 82 ; pls. 1, 4, 28.
Kotah, Rājputāna, 50, 266 :—Contt., 495 ; pls., 1, 5, 28.
Kuenlun Range, Central Asia, 146, 237, 506–7, 528.
Kuki Hills, NE. Frontier ; expn., 1859–60 ; 184, 442.
Kulu, Punjab Himālaya, 146, 201–2, 204, 271–2, 517, 528 ; pl. 16 (Kooloo).
Kumaun :—Hills, NWP., [III, pls. 1, 6], 16, 21, 34, 63, 81, 84, 86–7, 90, 105, 145, 147, 149, 167–8, 258–9, 261–6, 376, 448, 528, 531–2 :—Forests, 324 :—Maps, 316, 324 :—& Garhwāl Svy., 1863–1870, 238, 428, 508, 516, 532, 538.
Kundah Hills, Nilgiri, S. India, 167, 180, 280.
Kurnool, Madras, 172, 280, 283, 494 ; pl. 28.
Kurram R. & Valley, NWF., 215–7, 330, 498, 511 ; pls. 1, 2, 5, 28.
kyāng, or wild ass, 235, 481.
Kyaukpyu, Burma, 196, 495, 510.
Kyd :—St., Calcutta, 351 :—Dockyard, Kidderpore [I : 347], 69–71, 183.

Labour :—Forced, 32, 377 n.1, 477 :—Supply of, 31–2, 39, 51, 174, 197, 212, 470, 476–7.
Labourers, 18, 31, 39, 48, 108, 174, 528, 531, 536 ; v. Coolies.
Ladākh, trans-Himālaya, 201, 220, 240, 480 :—Contacts before 1855, 146–7, 187, 426, 448, 496, 528, 531, 536 :—Svy. of 1856–65, 5, 141, 157, 225, 227–6, 230–8, 425, 428, 489, 505–7, 513, 515 :—Maps, 239, 316, pls. 1, 5, 6, 13, 28 :—Pendulum Obsns., 1871, 490–1 :—Wazīr, or Supt., 508.
Lahore, Punjab, 7, 34–5, 43, 76, 118, 209, 229, 296, 314, 316, 337, 387, 427, 472, 482, 508 :—Agency, or Bd. of Admin., 1847–53 ; 36, 209–10, 215, 272, 349–50, 413, 472 n.4, 480 ns. 1, 2, 492, 513, 524, 536–7, 539 :—British Comnr., or Resdt., 34, 423, 524 :—Dist. Rev. Svy., 272–3 :—Metl. Obsy., 139 :—Rlwy., 375 :—School of Civ. Engrg., 446 ; pls. 1, 3, 5, 6, 16, 28.
Lahūl, Punjab Himālaya, 186, 201–4, 230, 271–2, 496, 517, 528 ; pl. 16.
Lakes :—Himālayan, 187, 220, 225–6, 228, 231, 228, 234–5, 237, 489, 515 :—Nilgiri Hills, 543 :—Salt-water, Calcutta, 70, 249.
Lallah Ram, rev. survr., 433, 441, 451.
La Martinière Sch., Calcutta, 23–4, 419, 439–40, 442.
Lambton, Lt.-Col. Wm. (1753–1823), BM. 33rd. Ft. ; STS., *from* 1818 [II, 411–15 ; III, 465–9] ; *DNB.* ; *DIB.*, vi, xiii 66, 69, 72, 121, 133, 142, 148, 150, 177, 339, 346, 365, 376, 380–1, 405, 408, 454, 472, 478 :—Triangles, xiv, 281.
Lamp :—black, 298, 329–30, 333 :—chimney, 14, 21, 45, 111, 373 :—Oil, *or chiragh*, 251 :—of svy. inst., 114, 116, 158 :—Referring, 117, 119, 503, 514 :—Signal, 23, 28–9, 41–2, 45, 57, 62, 102, 118 :—Argand, 223–4 ; v. Signallers.
Land :—Marks, 195, 265 ; v. Marks ; Pillars :—Owners, 8, 253, 272, 292, 299–301, 469, 476 :—Revenue, 6, 292 :—Svy., 292, 297, 338, 411, 447 :—holders, and tenants, 292, 477 ; v. Measts. ; *zamindars*.
Landour, Mussoorie [IV, pl. 17], 86, 138–9, 538.
Languages, 40.. 47, 240, 321–2, 386, 388, 437, 447, 494, 519, 526, 530, 535, 544 ; v. Hindustāni ; Persian.
Lanterns, 24, 224 ; v. Lamps.
Laplace, Pierre Simon, Mqs. de (1749–1827), French geodesist [III, 526], *RAS.* (*mn*), I (53) ; 132 n.7, 136.
Large-scale svys., 179, 245, 252, 259, 261–2, 277, 502 ; v. Towns.
Lārkāna, Sind, 45–6, 76–8, 278–9 ; pls. 1, 5, 28.
Lascars, 364, 453, 455, 473 :—Alice., 429, 455 ; v. Coolies ; Followers.
Lathes, 138, 154.
Latitude :—Astr. Obsns., 44, 130–6, 168, 234, 281, 286, 448, 503, 507, 523, 533–4, 540 :—Parallels of, xv, 97, 101, 123, 196 ; v. Murree.
Latitudes & Longitudes :—comps., 91, 121–3, 290, 525 :—Lists of, 125–7, 282, 296, 313 :—values, 120, 124–5, 131–2, 184, 147, 318, 368 ; v. Geog. positions.
Law courts, 202, 471.
Lawler, Wm., civ. asst. Trig., 20 n.4, 419.
Lawrence :—Sir Henry Montgomery (1806–57), Ben. Art. [IV, 434–4], Resdt. Lahore, 1846–8 ; AGG. 1849–53 ; Rājputāna, 1853–7, Oudh, 1857 ; *DNB.* ; *DIB.* ; KCB., 1856 ; Rev. Survr., 7, 256, 266, 272 n.3, 396, 418, 494, 509, 520, 524 :—John Laird Mair, Lord (1811–79), BCS., 1st Baron, 1869 [IV, 486], Ch. Comnr. Punjab, 1853–9 ; GGI. Council, 1859–64 ; GG. & 1st Viceroy, 1864–9 ; *DNB.* ; *DIB.* 200, 269 n.3, 397 n.2, 471, 482, 539 :—John Jackson (b. 1828) civ. asst. Trig., 19 n.1, 20 n.2, 22 n.2, 83, 272 n.3, 409, 419, 442, 473.
Lawrence Asylum Schools, Abu, Coonoor, Murree, Sanāwar, 442–3.
Lay-out of Maps, xv, 175–6 :— triangles, 11–60, *passim*, 97, 99, 105, 110, 114, 121, 156, 281, 409 ; v. Approx. Ser. ; Stations ; Triangles.
Lead, mineral, 142, 144 ; graphite, 186.
Leave :—in India, 41, 151, 349, 410, 412, 500 :—*to khalāsis*, 453, 455 :—Service without leave, 339, 414 ; v. England ; Furl. ; Sea ; Sick.
Lee, Dr. A. C., asst. surgn., Mar. Dept., 31, 461.
Leech, Maj. Robt. (1813–45), Bo. Engrs. [IV, 454] ; Conolly (106/98) ; x, 217.
Leeches, therapeutic 255, 460.
Leg, broken, 24, 397, 543.
Legal :—Action, 438 :—Authority, 182.
Leggatt, B. C. ; civ. Rev. Survr., Madras, 280, 445.
Leh, Ladākh, xiii, 85, 147, 187, 227, 232–40, 286, 489–91, 506–8, 512, 528, 531, 536 ; pls. 1, 3, 5, 6, 28.
Lela, Punjab, 214, 274–5 ; pls. 1, 5, 28.
Leigh, James, or John (b. 1815), civ. Asst. Topo., 169–71, 172 n.3, 178–9, 421–2, 431, 461.
Leopards, or panthers, 15, 467, 520.
Letters :—Anonymous, 413 :—Disrespectful, 412–3, 496–7, 526, 530–1 :—from Europe ; Walker's, 540 :—Lengthy, 532 :—to Ruling Princes, 480–1 :—withdrawn, 395, 526, 531 ; v. Correspondence.
Level :—to set inst., 84, 112, 117, 207 :—Flat ground, 63–9, 75, 217.
Level, spirit :—attachable, 43, 45, 63, 66, 82, 110, 114, 117, 153–4–5, 157–8, 474 :—Inst., optical, or dumpy, 8, 71–2, 75–7, 159, 186, 495, 539–40.
Levellers, Indian, 76–9, 160, 446, 531.
Levelling :—Calcutta, 21, 70–1, 181, 183, 504 :—Canals, Bind, 192, 397 :—Comps., 344 :—GTS. systematic, xv, 3, 42, 65, 75–80, 340, 367, 446, 492, 516, 539–40 :—Lines, of, 80, 121 :—Pamphlets, 80 :—Trgts, 62–3, 73–4–5, 533 :—by Rev. Survr., 256–63, 266 :—by Topo. Survrs., 214 :—GTS. Party, 370, 415, 506, 510, 525, 538 ; Staves, 62, 75–9, 159–60, 165–6 ; v. Insts.
Lhāsa, Tibet, 240, 512 ; pls., 1, 3, 4, 28.
Library, 78 :—Svy., Dehra Dūn, 335, 502.
Liddar R., Kashmir, 224, 226, 229, 505, 512.
Light, R.N.R., civ. rev. survr., Bo., 445.
Lighthouses, 15, 26, 41, 74, 174, 248, 504, 519, 526, 531.
Lightning, 188, 224, 228 :—conductor, 223, 514.
Lime, 89, 106, 148, 212, 223 :—Mortar, 20, 27, 112.
Line-clearing, 15, 17, 48, 52, 99–101, 253, 262, 274, 278–9, 448, 455–6 ; v. Jungle ; Rayn.
Linguist, 322, 434, 544 ; v. Languages.
Lingzi Tāng, Ladākh, 237, 506 ; pl. 6.
Lithographed :—Documents, 151 :—Forms, 122, 125, 327, 330 :—Maps : Geogl., 15, 142, 194, 196, 199, 200, 218–6, 219, 224–6, 307–8, 312, 316–7, 319, 323 :—Dist., 277, 296, 310–1, 313–5, 322–6 :—Postage Stamps, 9, 332–5 :—Pubns. 234 :—Rev. 277–9, 293, 294, 305–6, 325, 351–2 :—Town, 183, 186, 245, 250 :—Tables, 122–6 :—PRESS :—Govt. :—Bombay, 276 :—Calcutta, 9, 311, 313–6, 318, 320, 322–3, 325–7, 337, 348, 357 :—200., 9, 165, 194, 196–7, 294, 306, 323, 327–35, 336, 342, 348–9, 352–3, 357–5, 360, 537 :—Private, Calcutta, 185, 320, 325 :—London, 9, 238, 317, 320 :—Rev. Svy., Allahābād, 295 :—Madras, 9, 250 :—Poona, 276 :—Machine or Hand Presses, 9, 165, 194, 328–9, 332–3 :—Stones, 276, 315, 328–9, 331 ; v. Photo-Litho ; Zinco.
Lithography :—process, 276, 290, 311, 320, 326, 340, 496, 515, 537 :—in colour, 208, 239, 319, 329–30, 332–4, 515, 537.
Lloyd :—M. Gen. Geo. Wm. Aylmer (1789–1865), Ben. Inf. ; Hodson III (65–6), CB. ; 529 :—John Hayes, Bo. Inf., 401 :—Richd. (1797/8–1877) Bo. Mar. [III, 499] ; Mar. 80., 1838–40 ; Markham (27–8), 195–6 :—W., Civ. Engr., 208 n.5, 423.
Local Officials, xiv, 35, 113, 131, 177, 186, 264, 268, 293, 313, 318, 362, 454, 469, 485, 507 ; v. Dist. ; Kashmir.
Loftie, Edw. (b. 1827), civ. asst. Rev., 269 n.5, 433, 442.
Logarithm Lodge, The Park, Mussoorie [IV, 440], 531.
Logarithms, 4-page, 120, 124, 265 :—*Tables*, 123–4, 501, 529–30 ; v. Bagay's ; Hutton.
Long :—Richd. (1793–1855), civ. asst. Topo. [III, 385], 169 n.2, 171, 178, 421, 431 :—Richd. H., his son, 421, 431 ; both civ. asst. Topo.
Longitudes :—Astr. Obsns., 133, 196 n.6, 281, 448 :—by chronometer 147, 196 n.6, 538 :—in error 195 :—of Madras, xv, 125–6, 313 :—Telegraphic, 503, 540 :—Values, 120, 124, 130, 147, 196 ; v. chronometer ; Lats. & Longs ; Meridian.
Longitudinal series, GTS., xiv, 1, 97, 100–1, 130–1, 149 ; v. Bombay ; Calcutta ; Great ; NE. ; NW.
Low, James (b. 1840), civ. asst. Topo., 234, 236–7, 425, 431 :—M Gen. Sir John (1788–1880), Mad. Inf., GCSI., AGG., Rājputāna, 1848–52 ; 191 :—Wm., civ. asst. Trig., 25–6, 419, 431, 506–7 :—M Gen. S.E.D. (1813–88) ; Mad. Engrs. ; xi.
Low water, tidal, 69–70 ; v. High-water ; Tides.
Lubrication, 131, 153–4, 156, 163.
Lucknow, Oudh :—Cant. svy., 185 n.8 :—Obsy., 139, 532, 534 :—Resdt. & Readcy., 185, 314, 376, 478, 482, 509 :—Rev. Svy., 509, 539 :—Siege & Relief, 1857–8, 1, 12, 130, 139, 184, 380, 482, 493, 500, 505, 521, 528, 531, 534 ; pls. 1, 3, 4, 16, 28.
Ludhiāna, Punjab, 3, 37, 60, 216, 474, 493, 635 :—Rev. Svy., 269–70 ; pls. 1, 3, 5, 16, 28.
Ludlow, Frank (b. 1885), Bo. Educn. Dept 1908–23 ; 491 :—M Gen. Sam. Edgar Owen (1813–88) ; Mad. Engrs. ; Conolly (100/157) xi.

Lumsden, Lt.-Gen. Sir Harry Burnett (1841–66), The Guides, *DNB.*; *DIB.*; 475, 511:—Col. Thos. (1789–1874); Ben. Art., Hodson, III (96); 511.
Lyall, Dr. Robt. (1825–57), Ben. Med., Crawford, II (206–7); Opium Agent, Patna, 1854–7; 216.

Macaulay, Geo. Wm. (1828–1910), Bo. Inf., Comdt. 1st Sind Horse, 194.
Macdonald, Alex. (1765-1840) Marshal of France, *Ency Brit.*, 205:—John (1759–1831), Ben. Engrs. [II, x], FRS.; Hodson III (12-3), Conolly (84/57), *DNB.*, son of Flora Macdonald (1722–90), *DNB.*; 511:—Maj. of 2nd (Sirmoor Rifles) Goorkhas, 1871; 591 n.1.
McClelland John (1800–83), Ben. Med. [IV, 486]; FRCS., geolgt., arrd. 1830; Supt. Forests, Pegu, with geol. sketch, 1855, *IO Cat.* (308); [IV, 336]; Burkill, II (58, 67); III (687); v (758), 142, 196.
MacDougall, John W. (b. 1845), civ. asst. Trig., 1865–78; 490–1.
McGill:—Geo. A. (1838–92), civ. asst. Topo., 178–9, 428–9, 431, 485–6:—Jas. Hamilton (1827/8–53), civ. asst. Topo., 40, 44, 120, 178, 211, 421, 431:—John (b. 1830), civ. asst. Bo. Trig.; 54, 57, 73, 419, 518.
MacGrath, Capt. Fredk. (1804–51), Ben. Inf. [IV, 265]; Burma, 1836–7; 195.
Macintyre, Maj. Donald (1831–1903), Ben. Inf., 2nd. GR.; VC.; ret. as Hon. M. Gen. 1880; *DIB.*; *Who Was Who.*; 491 n.1.
Mackenzie, Lt.-Col. Colin (1753/4–1821), Mad. Engrs. [III, 474–83], CB., SG. Madras, 1810–5; India, 1815–21; xiii, 167, 281, 283, 346, 421, 478, 497 n.4:—James, Sgt. RE., Markham (455); 331 n.6.
Mackinnon, John (1806–70), Schmr., Ben. Art. & Mussoorie [IV, 163 n.7], v, 402, 422,:—Sch., Mussoorie [IV, 440 n.2], 432, 436, 505.
McLeod, Sir Donald Friell (1810–72), BCS. [IV, 288 n.1]; Comnr. trans-Sutlej, KCSI., CB.; LG. Punjab, 1865–70; *DNB.*; *DIB.*; 204–5:—Gen. Wm. Couperas (1805–80), Mad. Inf. [IV, 455]. lx.
MacMahon:—Alex. Ruxton (bapt., Calcutta, April 1830), Mad. Inf., 1847–79 MSC. & Burma Comn., 1856–78; 196–7, 244 n.2, 400:—Chas. Robt. (b. 1791), civ. asst. Mad. Topo. [IV, 386] vii, 179, 279, 290–1, 431.
McReddie, Geo. King (b. 1805), dmn. [IV, 486], 353, 359.
MacVicars, Wm. (b. 1805), dmn. [IV, 486], 353, 359.
MacVittie, Edw. Francis (b. 1842), civ. asst. Topo., 174, 176 n.6, 431.
Maddock, Sir Thos. Herbert (1790–1870), BCS.; Dep. Govr. Bengal, 1845, ret. 1849; *DIB.*; 182.
Madras:—Army & Troops, 378, 384, 466, 504, 526:—viii:—Estbt. 363, 428–9:—Govr., 180, 280:—Govt. Ft. St. 4, 8, 144, 167, 177, 180, 279–80, 347, 375, 377, 384–5, 526:—Harbour, 194:—*jagir*, 297:—*khalāsi*, 454:—Pay Code, 385, 429, 455, 526:—Presdcy., 143, 176; Town, xiii:—Rlwy., 375:—"Benighted", 386–7, 491, 543; v. Astr.; Maps; Obsy.
Madras:—Coast Ser. GTS., 29, 428, 432, 532–3:—DSG., 177, 280, 355, 385:—Dists., 167, 319:—Engrs., 179:—Lambton's Svy., xiii, 66:—REV. Svys., 6, 166, 279–80:—Rev. Svy. Dept., 319, 494–5, 503, 521:—Topo. Svys., 4, 29, 127, 167–8, 179–80, 281, 289, 385, 462:—Parties, xiv, 281, 288, 310, 426:—Survrs. & Assts., 283, 363, 400, 421, 426, 492–3, 500, 519, 525–7:—Allces., 398, 429, 496, 503:—Tidal Obsns., 69:—Town Svy., v, vii, x:—Univ., 494.
mafassal, or country dist., 411, 477.
Magisterial Powers, 299, 398, 526–7.
Magistrates, 113, 191, 252, 256–7, 322, 364, 374, 413–4, 484, 504, 522, 529:—Cant., 500.
Magnetic:—Bearing, 169, 190:—Meridian, or variation, 448:—Needle, 282, 288:—Obsy., 144, 162, 208, 532:—Svy., 144–6, 527–8.
Magnetism, 145, 527, 540.
Mahābaleshwar, W. Ghāts, 54–5, 461; pls. 1, 28.
Mahānadi R., Orissa, 170, 174, 283, 462, 525; pls. 1, 3, 4, 16, 28.
Maharājpur, Gwalior, battle of, 29–12–43, *c.* 20 m. S. of Dholpur, xi, 522–3.
Mahsūd Wazirs, NWF. tribe, 49, 217, 219, 490, 492, 508, 540.
Major, bt., local, or regtl., 348–9, 363, 379, 381–2, 384, 537, 539.
Malaria, xiv, 17, 25, 29, 337–8, 374, 417, 451, 454, 456, 459–60, 464–8, 519; v. Fever.
Malaya, including Malacca, 244, 349, 535–6.
Malby & Sons, engravers, London, 311.
Malda, Bengal:—Rev. Svy., 241, 245, 314, 452, 520:—Town svy., 245; pls. 1, 16, 28.
Maling, civ. asst. survr., Tenasserim, 1844, 194 n.6.
Maluncha:—North ser., GTS., 2, 12–5, 17, 19, 37, 83, 85, 99, 100, 104, 122, 128, 149, 160, 343, 361, 368, 371, 379, 409, 415, 453, 456, 467, 510, 520, 522–3, 541:—South ser., GTS., 2, 22–3, 25–6, 361, 504; pls. 3, 4.
Mālwa, Central India (I: pl. 24; III, pl. 9), 54, 188–9, 191, 490:—Malcolm's map [III, 84–6, 275], 188, 310, 315.
Mānasarowar Lake, Tibet [III, 527] 187–8, 316, 531; pls. 1, 3, 4, 16, 28.
Mānbhum Dist., Bengal, 6:—Rev. Svy., 243–4, 251, 364, 511, 528; v. Jungle Mahāls, IV, pl. 3; v, pl. 16.
Mandi State, Himālaya, 202, 204, 206, 471, 516–7; pls. 6, 16.
Mangalore Merdl. ser. GTS., W. Coast, 102; pl. 28.
Mango trees, 12, 23, 278, 478.
Manora, Karāchi, 42, 44, 74, 77–8, 80, 534, 539; pl. 5:—Lighthouse, 41.
Manson, Lt.-Col. James (1791–1862), Ben. Inf. [III, 484], 511.
Manual of Surveying (Thuillier & Smyth), xxvii, 162, 198, 243, 282–4, 288–9, 302, 338, 342, 365, 512, 521–2, 536.
Map:—Compilation, xv, 9, 194, 196–9, 214, 295, 312–5, 319–21, 340, 353, 428:—Depot, 321, 323–4, 348, 352, 482–3, 537:—War Office, London, 324:—Drawing, 9, 176, 198, 208, 214, 225, 270, 320–1, 348, 365, 414, 424–5, 428:—Heading & Footnotes, 291–2:—Index or Skeleton, 214, 239, 241, 307–8, 312, 315, 321:—Printing & Pubn., xv, 5, 9, 76, 194, 196, 318–9, 323, 349, 357, 537; in London, 317–9, 322, 326; v. Engraved; Lay-out.
Map:—Mounting, 238, 324:—Record & Issue (MRIO.), 270:—Reduction, 196, 214, 299, 316, 319, 331:—Sales, 182–3, 305–6, 323–4, 348, 351, 502, 537; v. Photographs; Projection.
Maps:—Demand, t-page 99, 320, 324, 337; v. Rlwys.:—Copied by hand, 305, 320, 324:—Damaged, 191, 270:—Destruction or Loss, 250, 305, 322, 326, 483:—General & Geogl., 68, 119, 146, 188–9, 307–9, 314–5, 350:—Piracy, 307, 316, 323:—Shortage, or Lack, 188–9, 194, 310–1, 322; v. Blanks.
Maps:—from GTS. ops., 103, 184:—Geogl. 498:—Mil. 193, 483, 537:—Provinces, 312:—Ordn. Svy., Gt. Bn., 113, 176:—Rlwys., 4, 374:—SCALES:—64-m., 9, 307, 309:—24-m., 316–7:—32-m., 9, 308–9:—16-m., 312, 314–5, 319:—8-m., 5, 189, 196, 312, 314–6, 320–1, 324:—Topo. 7, 10, 68–9, 119, 146, 170–1, 188–9, 211, 213–4, 216–7, 276, 336, 340; v. Charts; Geol.; Rev. Svys.; Village
Maps of:—Bengal Dists., 119, 296, 307, 348:—Bombay, 7, 310:—Burma, ix, 5, 194, 196, 497–8:—Europe, 146:—Himālaya, 187, 204, 324:—Hdbd., 177, 307–9, of India, xiii, 145–6:—Kashmir, viii, x, 5, 9, 87, 231, 233, 238–9, 316, 319, 342, 515:—NWP., 119, 185, 312, 324, 327, 357:—Nilgiri Hills, 384:—Orissa, ix, 526–7:—Oudh, 314:—Punjab & NWF., 35, 51, 76, 119, 209, 213–4, 219, 284–5, 316–8, 324, 424, 427:—Rājputāna, 313–6, 324:—S. India, vii, 310, 319:—Sind, 192–4; v. Assam; Bihār; Calcutta; Central India; Pegu.
Marātha:—Language, 530:—People, xiii, 447:—South M. Country (SMC), Rev. Svy. [IV, pl. 1], 275–7, 398, 488, 494, 498, 510; pl. 28, Dhārwār.
Marches:—on duty, 41, 158, 176, 210, 216, 337–8, 370, 484, 534:—on transfer, 371, 438.
Marine:—Board, Calcutta, 71 n.3:—DEPT., Calcutta, 15, 57, 461:—Bombay, viii, 72–3:—SERVICE:—Bengal, 196, 437:—Svy. Dept., 1874, 73 n.1.
Mariners, or Sailors, 139, 519.
Marines, Royal (British), 484.
Markets, 253, 362, 477.
Markham's: *Memoir on the Indian Surveys* xvi, xxvi, 158–9, 311, 321, 417, 512:—*Abstract*, 509.
Markhor, mountain goat, 481, 515.
Marks:—Cultivation limits, 275:—GTS. Stations, 27, 46, 48, 50, 98, 105, 108–10, 112–4, 120, 190, 228, 235, 406, 472:—Destroyed, 469:—Rock-cut 105, 112:—Topo. Stations, 212, 286; v. Navigation; Referring; Boundary.
Markstones:—Base-lines, 20, 42:—Disturbed, 50, 60, 113, 190, 212, 469–70:—GTS. Stations, 97, 99, 105–7, 109–10, 112–3, 138:—Preservation, 112–3, 131:—Rev. Svy. conn. 295–6; v. Centering.
Marriage, 369 n.3, 410 n.1, 427, 429, 488–543, *passim*.
Marriott, civ. survr., Prov. Wellesley, Malaya; 244 n.1.
Martaban, Burma, 194, 244, 425, 542.
Mason, Lt.-Col. Kenneth (b. 1887), RE., MC., S of I. 1909–34; Prof. Geog., Oxford Univ., 1934–52; xvi, 83 n.3, 92, 96, 489, 507, 515 ns. 6, 7.
Masonry:—dry-stone, 24, 112–3:—mud-bound, 112:—Marks, 295–7:—Pillars, for insts., 99, 105, 112:—for rev. svy. control, 131:—Platforms, 98, 262:—Towers, 105.
Masons, stoneworkers, 18, 39, 110, 112, 296.
Masherbrum Pk., K 1, 25,662 ft., Karakoram, 88–9.
Massacre, 267, 435, 483.
Masters:—Lt.-Col. John (b. 1914), IA., DSO., auth., 419:—Wm., civ. asst. Trig., 90 n.6, 410 n.3, 419.
Masts, for signals, 24–5, 90.
Masulipatam, E. Coast, rev. svy., 280, 494, 521; pl. 28.
Mate, or select *khalāsi*, 452, 455.
Mathematical:—Ability, 340, 382, 530, 533–4, 541:—Education, 522, 526:—Papers, 529:—INST. MAKER, 9–10, 20, 44, 152–3, 160, 162, 164–6, 299, 329, 357–8:—Asst., 358, 360:—Dept., 140, 163–5, 322, 336, 340, 342, 357–8:—OFFICE (MIO.), 151, 352 n.3; v. Supt.; Workshop.
Mathematicians, 136, 178, 388, 390–1, 414, 425, 427, 501, 520, 524 534, 544.
Mathematics, 380–1, 383, 389–90, 397, 411, 402–3, 417, 423–5, 448–9, 492, 501–3, 513, 522, 526, 533–4.
Mathison, Lt.-Col. Robt. (1807–87), Ben. Inf. [IV, 457], 6, 241, 246, 299, 303, 364, 433–4.
Mauritius I., Indian Ocean, 348, 356, 531.
mauza, village, as fiscal area, 263:—*mauzawar*, village by village 246–7, 274, 278.
Maxwell:—Henry Hamilton (1824–93), Ben. Art., 186:—Wm. (1814–82), Ben. Art. [IV, 457], 241, 251, 384, 433.
May:—John Albert (1841–86), civ. asst. Topo., 176 n.2, 431:—Robt. (b. 1830), civ. asst. Rev., 433, 442.
Mayurbhanj, State, Orissa, 27, 168 n.5, 170, 172, 175–6.
Measurements, rev. svy., 280, 292; v. Indian; Perambulators.
Meat supply, 32, 466.
Mecca, Arabia, 302 n.2, 473, 494, 505.
Mecham, Richd. (1826–59), Ben. Art., kd. by tribesmen, 5–11–59, 219.
Mechanic, 153, 164, 279, 392–3:—repairs, 44, 533:—skilled, 10, 44, 154, 158, 532, 534.
Medals:—Exhibition, 331 518:—Mil. Service, 495, 508, 523, 539:—RGS., 339, 519.
Medical:—Aid, 16, 168, 410, 454, 458–60:—Board, 520:—Certificate, 31, 48, 257, 343, 382, 497–8, 501–2, 522, 529, 539–40, 542:—Charge of fd. party, 20, 142, 173, 457, 459, 464:—Coll., Calcutta, 140:—Compounders, 457:—Instns., 169, 526:—Officers, 31, 139, 142–3, 171, 216 n4, 536:—Treatment & Science, 456–66, 500; v. Doctors; Surgeons.
Medicines, 168, 210, 373, 391, 438, 456, 458–60, 464; v. Emetics.
Medlicott, Henry Benedict (1829–1905), FGS., FRS., GSI., 1854–87 Dir. from 1878; *Who Was Who*; *DIB.*; 143.
Meerut, NWF., 1, 50, 80–1, 150, 228, 313–4, 337, 372, 374, 376, 482–3, 498–500, 535:—Cant. Svy., 185 n.8; pls. 1, 3, 4, 5, 16, 28.
Meghasāni Hill, Orissa, 175, 466; pls. 1, 28.
Meghna R., E. Bengal, 6, 242–3, 256.
Memoirs:—Descriptive, 177, 187, 220:—Personal, 527:—Statistical, 180.
Memory, loss of, 238, 519, 529, 531.
Meneaud, Augustus (b. 1808), civ. asst. Topo. [IV, 386], 360, 421, 431.

Merchants :—Asiatic, 448, 507 :—German, 501.
Mercury or Quicksilver :—Barometers, 69–70 :—medicinal, 461 :—reflecting, 261 :—Sulphide, 332 n.4.
Meridian of longde., 97, 101 :—astr. obsns., 130 :—convergency, 298, 530 :—lines on maps, 128, 125, 181, 313 :—Marks, 113 ; v. Graticules ; Longitudes ; Projections.
Meridional chains of triangles ; v. Subordinate.
Merriah sacrifices, human, 167, 169–70, 386, 527.
Merwara, Rājputāna, 6, 265–6, 864 ; v. Ajmer.
Metals, antimony, lead, 142, 144 ; v. Brass, Gold, Iron, Silver.
Meteorological :—Dept., 1, 140 :—Obsns., 76, 138–9, 145, 356, 503 :—Records, 78, 139 :—Obsy. 189.
Meteorology, 139–40, 145.
Metric System, 534.
Meywar Bhil Corps, Rājputāna, 89.
Mhow, Central India, 55–6, 392, 523 ; v. Indore ; pls. 1, 3, 28.
Miānwāli Dist., Sind-Sāgar *doāb*, Punjab, 47, 80, 274 ; pl. 16.
Miasma, jungle, 456–7, 459, 462, 465–6 ; v. Fever.
Micrometers, 115, 117, 120, 148, 151, 154, 287.
Microscopes :—of base-line bars, 97, 158–9 :—of theodolites, 98, 115–6, 121, 153–4, 520, 533 :—Research, 489.
Midnapore, Bengal :—Cadastral Svy., 1872–6, 435 :—Cants, 23–4, 26, 504, 525 :—Dist., 22, 29 :—Maps, ix, 311 :—Rev. Svy., 5–6, 241–2, 246–7, 295, 299, 303–4, 364, 395, 433, 435, 450, 510, 528 :—Topo. Svy., 172, 175 :—Town Svy., 525 :—Trgn., 29, 462 ; pls. 1, 3, 4, 16, 28.
Mile, of 1,760 yds., 160, 162.
Military :—Authority, 377 :—Allces., 340, 358, 398, 407, 489, 502 :—Board, Bengal, 162, 164, 309, 315, 358 :—Dept., Govt. of India, 363 :—Duty, 14, 28, 58, 209, 241, 266, 269, 275, 338, 382, 384, 482–3, 493, 499 :—Drawing, 291, 341, 383 :—Expns., 49, 184, 194, 215, 217, 219, 481, 489–90, 509, 527 :—Instn., Madras [II, 314–32], 176, 288 :—Maps, 35, 200–1, 214, 285, 317 :—Opns. 1, 167–8, 189, 268, 310, 377, 481–3, 485, 518, 537 :—Orphan ; School, Calcutta, 441, 444 :—Rank, 336–40, 345, 381–2, 388–9, 407 :—Reversion to Unit, 384, 499, 526, 530–1, 533 :—Route svys., 310 :—Sec. to GG., 238, 349 :—Society, 329 :—Svy. & Recce., 2, 4, 189, 208, 210, 214–5, 218, 380, 387, 423.
Military Officers, 370 :—GTS., 336, 379–80, 399 :—REV. SVYS. :—Bengal, 304, 395–6, 400, 433 :—Bombay, 8, 276, 293, 400–1, 475 :—TOPO. SVYS., xiv, 316, 399–400, 421, 426 :—*subadar*, 89, 484 :—*risaldar*, 428 ; v. British ; Cavalry ; GTS., Infantry ; Kashmir.
Milk, 459, 461, 479.
Millard, Sgt. Henry (1819/20–57), b. London, arrd. Bengal 1839 ; Engr. ; 2nd Ben. Eur. ; to Rev. Svy., 16–9–47 ; sub-asst. ; 200, 260 n.1, 433, 442, 483 n.1.
Miller, Col. Henry Newdick (1826–87), Bo. Inf., with Guides, NWF., DIG. Police, Punjab ; 216.
Minerals, borax, *cornelian*, 142–4, 171–2, 386, 501, 505 ; v. Coal ; Lime.
Mines, Sch. of., London, 505, 526.
Minor Trgn., 2–14, *passim* 18, 296, *passim* 409, 416, 423, 458, 471, 483, 501, 506, 509, 516, 519, 525.
Mint :—Bombay, 530 :—Calcutta, 307–8, 332 :—Master, 380, 534–5.
Mirage, 2, 40, 58, 62, 65, 117–8, 212, 467.
Mirza Muhd. Haidar Dughlāt, Kāshgar, ruled Kashmir 1541–51 ; 240.
Mirza Sajjad, or Shuja (d. 1873), survr., "The Mirza", *GJ.* LXII, 1923 (429–40) ; 47, 215, 447–8.
Mirzāpur, NWP., Dist., 12, 284, 452 :—Mgte., 374 :—Maps, 296 n.2, 326 :—Rev. Svy., 8, 450 :—Town, 438, 541 ; pls. 1, 3, 16, 28.
Misconduct, 412–4, 437.
misl, or khasrah regr., 247, 254, 300, 302 ; v. *thakbast*.
Missions :—Christian, 33, 196, 447 :—Missionaries, 416 ; v. Political.
Mist, or fog, 46, 207, 287, 467–8 ; v. Cloud ; Fog ; Haze.
Mitchell, Col. Sir Thos. Livingstone (1792–1855), SG. NSW., Australia, FRS., 1828, *DNB.* ; 339.
Mithankot, on Indus, 3–4, 44–5, 48–9, 53, 79–80, 209–10, 217–8, 338, 484, 490, 509, 513, 541 ; pls. 1, 3, 5, 16, 28.
Mohsin Husain, Saiyad Mir (d. 1864), Mathl-Inst. Maker [IV, 458], 10, 20, 34, 44, 71, 130, 148–9, 151–6, 158, 162, 164, 288, 329, 357–8, 360.
mohwa trees, *bassia latifolia*, 23, 175.
Money :—lender, 412 :—market, Calcutta, 522 :—paper, 483, 534.
Money, Sir Alonzo (1821–1902), BCS., 1843–78 ; KCMG., CB., Comnr. Public Debt., Cairo, from 1880 ; *DIB.* ; *Who Was Who* ; 242.
Monghyr, Bihār :—Dist., 15, 142, 454, 511 :—Rev. Svy., 241, 254–6, 299, 302, 454, 529 :—Town, 13–4, 16, 19, 29, 101, 255, 288, 337, 368, 371 ; pls. 1, 3, 28.
Monsoon, or rains :—Assam, 369, 468 :—Bengal, 14, 20, 23, 29–30, 70, 83, 106–7, 264, 303, 336, 366, 368–9, 409 :—Mussoorie, NWT., 44, 122, 267, 370, 456, 496 :—Orissa, 26, 174, 367, 463–4, 525 :—Gujarāt, 58, 450 :—Punjab, 86, 77, 209, 524, 544 :—Kashmir, 224–5, 227, 229, 386 :—Rājputāna, 38, 40, 453, 523 :—Sind, 158, 371 :—South India, 365, 543 :—Christmas Rains, or NE. Monsoon, 17, 51, 52 n.5, 463 n.3, 467.
Montgomerie :—Hastings Seton (1872–1949), solctr., son of T. G. M., 513–4 :—Wm. (b. 1821), civ. asst. survr., Burma, Topo., 198–9, 244 n.2, 525, 431.
Montgomery, Sir Henry Conyngham (1803–78), Bart., MOS., 279 :—*Dist., Punjab*, 272–3, *formerly* Soogaira ; pl. 16.
Monumental Inscriptions (MI.), 491, 493.
Mooli, or Munt Mal, Peak, 14,936 ft., Pir Panjāl, 87, 222 n.5, 223–4.
Moon, 226, 465, 528.
Moorcroft, Wm. (*c.* 1786–1825), vet. surg. [II, 430–1 ; III, 485–7], vi, viii, 145, 186–7, 220, 317, 445, 528.
Moradābād, NWP., rev. svy., 258–62, 313, 434, 538, 543 ; pls. 1, 3, 16, 28.
Moran :—Francis (b. 1812/3) [IV, 284], 442 :—John Kenneth (b. 1835), civ. asst. Rev., 184, 434, 442, 528.
Morari Tso, trans-Himālayan lake ; pl. 6 ; 186, 234–5.
Morland, Lt.-Col. Henry (1603–68), Mad. Inf. [III, 458–9], ix, 3, 177, 363, 383–4, 400, 421, 428, 478, 493.
Morrison, Chas., Regtr., SGO. 1830–41 [IV, 350], 372 :—Brig.-Gen. Joseph Wanton (d. 1826), HM. 44th Ft. [III, 68 n.1], 195.
Mortality, 16, 362, 428 ; v. Deaths.
Mosquito, 256, 421, 456, 466 :—curtains, 464, 466.
Mounds, or hillocks, 46, 48, 50, 104, 108–9, 112.
Mount Abu, hill & station, 3, 38–9, 53–4, 57, 99, 117, 132, 416 ; v. Abu ; pls. 1, 5, 28.
Mountain :—Massif, 88 n.3, 94–6 :—Ranges, xiii :—Sickness, 204 :—Svys., 423, 425, 452 ; v. Allces. ; Attraction ; Hill.
Mountaineers, 389, 417, 489, 506–8, 518.
Mountainous Country, 68, 97, 149, 151, 157, 179, 200–8, 214, 221, 278 ; v. Hilly.
Mountains :—NW. Himālaya, 422 :—NE. Frontier, 194 :—Tibetan 87 :—Trgn., 35–6, 75, 82–9, 157 ; v. Himālaya.
Mud :—24–5, 57, 59, 78, 162 :—plaster or cement, 112.
Mudge, M. Gen. Wm. (1762–1820), RA., FRS. ; *DNB.* ; Dir. OS. 1798–1820 ; 339.
Mughal Emperors of Delhi [I : Index, sv. Emperors ; II, 464, sv. Delhi], 89, 240.
mujmal, summary or abstract, 259.
Muhammadan, mussalman, or muslim, 200, 240, 448, 459, 473.
Mulheran, Owen (1818–*c.* 1853), civ. asst. Trig. [IV, 487], 200 n.2, 419, 516.
Mullins :—Chas. (b. 1809–10), 242, 244 n.6, 433, 442 :—Chas. Wm. 248–9, 442 ; pr. cousins, both civ. assts. Rev. [IV, 487].
Municipality :—Calcutta, 181, 537 :—Mussoorie, 137–8, 502, 523.
Munro, M. Gen., Sir Thos. (1721–1827), Mad. Inf. [II, 433], 8, 279, 292.
Munrow (d. 1857), civ. asst. Rev., 442, 483 n.1.
munshi, muslim teacher, 215, 281, 278, 365, 423, 543–4, 480–1, 494, 524.
Murder, 146, 219, 448, 507, 527–8.
Multān, Punjab, 7, 35, 43, 49, 77, 316, 337, 371–2, 483, 489, 523, 532 :—Siege, 1848/9, 498, 500, 539 :—Dist. Rev. Svy., 272–3 ; pls. 1, 3, 5, 16, 28.
Murray :—Capt. James (1834–1904) ; Ben. Inf. x, xi, :—Maj. Wm. (1791–1831), Ben. Inf., vii, x.
Murree, Punjab, 27 n.6, 224, 469, 485, 492, 498, 505, 508, 514, 518, 525 :—Lat. Obsn., 133, :—Obsy., 133, 139, 337 :—Recess Qrs., 48, 53, 211, 213, 216, 219, 274, 370, 397, 482, 488, 490, 500, 524, 531, 539 ; pls. 1, 5, 13, 28.
Murshidābād, Bengal, Rev. Svy., 6, 185 n.8, 241, 243, 250, 255, 372, 499, 529 ; pls. 1, 3, 16, 28.
Museum :—ASB., Calcutta, 481 :—Svy., Dehra Dūn, 120, 153, 155, 159 ns. 2, 4, 235 n.7, 516, 531 :—Fitzwilliam, Camb., 490 :—Indian, Calcutta, 489.
Musgrove, J., litho. dmn., 330, 357, 360.
Muskets, 150, 377, 474, 539.
Mussoorie, NWP., 43, 86, 136, 145, 201–2, 204, 207, 216, 422, 427, 488, 502 :—Cemetery, 511 :—Climate, 516, 518, 543 :—Expences, 369 n.3 :—Maps, 138 n.7 :—Obsy., 137–8 :—Recess Qrs., 18, 50, 84, 90, 353, 369, 393, 410, 489, 496–7, 500, 511, 539 :—Schools, 402, 432, 436, 505 ; 122, 336–7, 343, 352 n.3, 482, 524, 537, 541 ; pls. 1, 3, 28 ; v. Mackinnon ; Monsoon ; Stokes ; SG.'s Hdqrs.
Mustāgh Range, Karakoram, 236, 488–9.
Mutineers, 1857, 1, 31, 396, 482–5, 492, 515 :—Svy. casualties, 6, 267, 364, 396, 400, 439, 442, 444, 483, 494, 538 ; v. Massacre.
Mutiny, 1857, 1, 5–6, 48, 50–1, 53, 151, 179, 189, 213, 228, 238, 266, 268, 314, 320, 364, 374 n.2, 465, 482–6, 488, 526, 534 :—Disturbances of 1857–9, 1, 48, 87, 213, 228, 230, 238, 268, 331, 349, 446, 376, 481–6, 509, 526, 532 :—Mil. campaigns, 310, 505, 535 ; v. Delhi ; Lucknow.
mutsuddis, rev. svy. assts., 183, 271, 365, 434, 439–42, 450–2.
Muttra, NWP., Rev. Svy., 309, 450 ; pls. 1, 3, 5, 16, 28.
Muzaffarābād, Kashmir, 225, 230 ; pls. 1, 5, 6, 13, 28.
Muzaffarpur, or Tirhut, Bihār, 5, 13, 19, 82, 241, 368, 543 :—city svy., 252 ; pls. 1, 28 ; v. Tirhut.
Mymensingh, Bengal, 253–4, 322, 373, 512–3 :—Rev. Svy., 5, 241–3, 253–4, 434–5, 438, 543 :—city svy., 252 ; pls. 1, 3, 4, 16, 28.
Mysore, S. India, v, xiii, 144–5, 478, 543 :—Rev. Svy., 488 :—Topo. Svy., 538 ; pl. 28.

Nadia Dist., Bengal, Rev. Svy., 6, 241, 243, 250, 255, 525 ; pls. 1 (Nuddeah), 16, 28.
Nāga Hills, Assam, 145, 183–4, 489.
Nāgpur, CP. :—British occupation, 405 :—City, 482 :—Rāja of, 178, 517 :—Rev. Svy., 268, 368, 398, 486, 519, 538 :—Topo. Svy. of, 1824–31, 268, 343 :—Territories, 1, 172, 189, 266, 343, 386 :—Trgn., 179, 268 :—, 1, 3, 4, 16, 28.
Nāhan, Sirmūr, 34, 200–1, 206 ; pl. 6.
naik, or corporal, 341, 377, 454, 474.
Nain Sin Pandit (1830–95), explorer, CIE., portrait 51. Records, VIII (frpce), 448, 528.
Naini Tāl, Kumaun, 260 n.1, 264, 266, 318, 324, 482, 485, 495, 499, 531, 539 :—Town svy., 259 ; pls. 1, 4.
Names :—of places mapped, 257, 296, 311, 313, 320–1, 330 :—Personal, 495 n.1, 496, 522, 529 :—of Survrs. recorded, 122, 292, 345 :—Trig. Pts. & Stns., 117, 121, 489, 514 ; v. Orthography ; Peaks ; Villages.
Nāmiruddin, engraver, 332 n.5, 335, 357.
Nanda Devi Pk., 25,640 ft., Kumaun, 8, 84, 91, 145, 187, 528 ; pls. 1, 3, 28.
Nanga Parbat, or Diāmar, 26,660 ft., Kashmir, 86–8, 223, 227, 230, 239, 337, 514, 528 ; pls. 1, 3, 5, 6, 13, 28.
Napier :—Gen. Sir Chas. James (1782–1853), 33rd Ft. 1794 ; conquest of Sind, 1842–4 ; Govr. 1844–7 ; C-in-C., India, 1849–50, GCB., 1843, *DNB. DIB.* ; 217, 494, 532 :—Lord, of Magdala, Robt. Cornelius (1810–90), Ben. Engrs. 1826, FM., 1883 ; Conolly (87/146) ; FRS., 1859, Civ. Engr. Punjab, 1849–56 ; C-in-C. India, 1870–6 ; *DNB.* ; *DIB.* ; 209 n.1, 272, 524.
Napoleon Bonaparte (1769–1821) ; Emperor of France, 205, 283.
Narbada R., CI., 55, 143, 189–90, 192, 324, 462, 523 ; pls. 1, 3, 28.
Nash, Alex. (1815–47), Bo. Engrs. [IV, 459] ; Conolly (106/103), 8, 376, 401 :—G. E., civ. asst. Rev., 442.

Nāsik, Bombay, 275, 375 :—Rev. Svy., 398, 495, 498, 511, 533 ; pls. 1, 6.
Nasirābād, Rājputāna, 51, 371, 438, 488, 490 ; pls. 1, 5, 28.
Nasri Batt., later 1st. Gurkha Rifles [III, 40 n.5 ; IV, 444], 519.
Native Est., 361 ; v. Doctors ; Followers ; Indian.
Natural History, 141-2, 146, 528.
Nature, scientific weekly, London, 92 n.1, 95 n.5, 96.
Nautical Almanac, annual pubn., 131.
Indian Navy, 58, 73-4.
Navigation :—59 :—Insts., 131 :—Marks, 15, 25, 519 :—Obsns., 411.
Neale, Clarence H. T. (b. 1840), civ. asst. Topo., 190, 210 n.3, 213, 227, 229, 232 n.4, 424, 432.
Nela Pass & Pk., Upper Ganges, 207-8, 505, 517.
Nellore, Madras :—Topo. Svy., 179, 280, 383, 504 ; pl. 28.
Nelson, Horatio (*c.* 1790-1839) Rev. Survr. [III, 489-90], viii, x.
Nepāl ; *Account of*...by Buchanan-Hamilton, Edinburgh, 1819 ; 82.
Nepāl, Himālayas, 81, 83 :—Bdy. or Frontier, viii, 13, 19, 185-6, 241, 244, 252, 314, 364, 529 :—Foot-hills, 105 :—Entry forbidden, 16, 81, 85, 94-5, 145-6, 522 :—Govt., 85, 92, 264 :—Map, 318 :—Resdt., 85 n.4, 94 :—Snow peaks, 86, 90-6, 204, 502 :—Trade, 501.
Nepalese people, 185, 252, 264, 473.
Neuville, Chas. Joseph (b. 1834), civ. asst. Trig., 233-5, 372, 419, 425.
Neve, Arthur (1858-1919), FRCS., of Kashmir, xxvii 224, 240.
Nevill, Henry (1820-69), MCS., 1840 ; Resdt. Travancore 1864, 280.
New :—York, 505 :—Zealand, 535-6.
Newspapers, 325 n.4, 357, 472, 512 n.2 ; v. Press.
Nichterlein, John, indigo planter, Aligarh, 501.
Nield, Chas. Bridgman (b. 1821), civ. asst. Trig., 14, 24-5, 463.
Night marches, 162, 187.
Nīlgiri Hills, S. India :—Health resort, 28, 177, 379, 445, 466, 495, 504, 527, 542-3 :—Ouchterlony's Svy., 8, 179-80, 279, 281, 290-1, 297, 363, 383-4, 421, 519 :—Solar Eclipse, 1871, 502 ; v. Ootacamund:—nr. Balasore, Orissa, 168-9.
Nimach, Rājputāna, 3, 38, 51, 55-6, 392, 452, 500, 523, 532 :—Rev. Svy., 6, 266, 364, 436, 495, 505, 539 ; pls. 1, 3, 5, 16, 28.
Nirmal, Hdbd., 416, 460, 462, 479 ; pls. 1, 28.
Nizām, 178 :—Army & mil. service, 267 n.5, 419 :—Dominions or Territories ; v. Hyderābād.
Noākhāli, or Bhuluah, Dist., E. Bengal, 242, 256 ; pls. 1, 16, 28.
Nominal Rolls, xvi :—submitted by fd. parties, 361, 364, 453 :—CIV. ASSTS. :—GTS. 418-20 :—REV. ; Bengal, 439-44 :—Bombay, 444-5 :—Madras 445 :—Topo., 430-2 :—MIL. SURVRS., GTS., 399:—Rev. Bengal, 400 :—Bombay, 400-1 :— Madras, 401 :—Topo., 399-400 :—SGO., Calcutta, 359-60.
Non-comnd. offrs. (NCO.'s), British, 331, 358, 524.
Norris, Lieut. Francis Brooke, Nāgpur Service [III, 490-1], 343.
North Longl., Conng. ser., GTS., Kumaun-Rohilkhand, 1, 11, 16, 18, 21, 34, 81, 86, 125, 132, 135, 156, 361, 381, 496, 516, 519.
NE. Frontier, GTS., 1 :—Topo. Svys., 183-4, 311-2, 512.
NE. Longl. ser. GTS., 2, 11, 13-9, 44, 66-7, 75, 97, 100, 107, 132, 137, 148-50, 155-6, 185, 361, 410, 416, 457, 467, 501, 510-1, 519-20, 541 :—Comps., 90-1, 128-9, 343-4, 417, 501 :—W. section, 21, 29, 86, 153, 376, 520, 523 :—obsn. of Snow Peaks, 17-20, 81-6, 90-5, 416, 501, 519-20 ; pls. 3, 4.
NE. Quadrilateral, 1-2, 11-21, 29-33, 97, 107, 129, 521 ; pl. 4.
NW. :—India, 499 :—Frontier Agency, Ambāla, 269, 380, 508 :—Rev. & Topo. Svys., 363, 377, 396, 436, 508-9 ; v. Mil. Expns.
NW. Himālaya longl. ser., GTS., 49, 52, 66, 76, 87, 113, 118, 123, 132-3, 136-7, 221, 239, 286, 347, 405, 429 :—under Du Vernet, 2, 12, 34-6, 38, 86, 98, 115, 124, 148-9, 152-3, 156-7, 200, 220, 271-2, 337, 363, 379, 385, 393-4, 422, 472, 474, 479-80, 496-7, 500, 505, 516, 532 :—under Logan, 2, 18, 36-7, 42, 50, 86, 119, 209-10, 221, 296, 375, 472, 490, 511 :—Comps., 344.
NW. Himālaya Topo., 2, 4-5, 36, 136, 200-8, 220-1, 271, 311, 318, 286, 393, 417, 422-3, 426, 471, 478-80, 496-7, 505, 509, 516-7 :—½-inch Maps, 310-1, 318-9, 330-1.
NW. Provinces :—188, 312-4, 320, 325, 337 :—Dist. Maps., 313-4, 325-6 :—16-m Maps, 315 :—Govt., 137-8, 258, 264, 267, 293-4, 315, 353, 418 :—Lt.-Govr., 211, 262, 266, 282, 313-4 :—Rev. Svys., xiv, 5, 7, 185, 193, 242, 256, 258, 276, 284, 293, 295, 297, 314, 321, 351, 364, 396, 536 :—Towers, GTS., 107, 113.
NW. quadrilateral, 2-3, 34-53, 129 ; pl. 5.
Norwood, Richd. (c. 1590-1675), mathn. & geodesist ; survd. Bermuda where he died ; *DNB.*, 297.
Nott, Gen. Sir Wm. (1782-1845) ; *DNB.* ; *DIB.* ; *Ency Brit.* ; 495.
Nowgong, Assam, 183-4, 362 ; pls. 1, 28.
Nubra R., Karakoram, 187, 425, 506.
Nun Kun, or Ser Mer, Himālaya Peaks, 23,410 ft. ; 87-8, 223, 230 n.3, 235-6, 239, 513 ; pls., 6, 13 ; Ser or Nana.

Oak trees, 222, 543.
Oakes, Col. Richd. Francis (b. 27-7-31), Mad. Engrs. 1850-76 ; Conolly (101/202) ; *REJ.*, June 1901 ; son of T. A. Oakes, MCS. ; 195-6.
Observations:—Corresponding, 131, 139 ; v. Barometer :—GTS., trgn. xiv, 11-63, *passim* ; 98-9, 105, 114-7, 148, 222, 225, 232, 409 :—Faulty, 329-5, 497, 523 :—Levelling, 77 :—Reduced to Centre, 176 Topo., 210, 287, 382, 402, 409 ; v. Astr. ; Recording ; Star Tidal ; Vertical.
Observatories :—Calcutta, 70, 138-9-40, 338, 343, 351, 354, 356-7, 414, 522, 532 :—Dehra Dūn, 124, 138, 343 :—Field, 112-8, 116-8, 233, 409-10, 446, 469, 501 :—Greenwich, 124, 140, 503, 531 :—Karāchi, 130-1, 470, 534 :—Madras, 124-5, 139, 144, 148, 532, 534 :—Simla, Singapore, 144 :—v. Banog, Colāba, Cape Town, Kallānpur, Lucknow, Magnetic, Met, Murree, Mussoorie.
Observers, 121, 138 :—Skilled, GTS., xiv, 13, 114, 116-7, 381, 405, 407-8, 415, 427.
Obstacles :—to line of sight, 102 :—to svy., 191, 467.
O'Donel, James Hugh (1819/20-72), civ. asst. Rev. [IV, 488], 242-4, 255, 304, 364, 433-5, 439, 448, 538 :—James Hoppner, his son, (b. *c.*, 1845), civ. asst. Rev., 442.
Office :—Asstt., Rev. Svy., 434, 439 :—Buildings, 138, 341, 351-2 :—Hours, 329, 332-3, 342-3, 361-2, 458, 483, 491, 502 :—Routine, 166, 451, 525 :—Staff, 458.
Officials :—Govt., free issue of maps, 327 ; v. British ; Civil ; Dist. ; Kashmir ; Local.
Offset measts., 297 ; v. Cross-staff.
O'Hara, civ. survr., Penang, 244 n.1.
Oil :—deposits, Assam, 145 :—LUBRICANT :—Goose or Duck, 163, 298 :—Linseed, 329 :—Mustard, 330 :—Olive, 298 :—vegetable, 373.
Okmandel, Kāthiāwār, fd. force, 1859-60 ; 500, 518.
Oldham, Dr. Thos. (1816-78) ; geolgt., Dir. GSI. 1851-76 ; FRS. 1848, FGS ; *DNB.* ; *DIB.* ; *Ency Brit.*, 142-4, 318, 535 :—Richd. Dixon (1858-1936), geolgt. ; FGS. ; GSI. 1879-1904 ; 137.
Oliver, Thos. (1780-1872), Ben. Inf. [III, 491] ; 264 :—Wm., Henry (d., Masri., 1859), Ben. Engrs. ; Conolly (93/318), 399.
Olliver :—Andrew Cornelius (1822-56), clerk, 341, 359 :—Chas. Adolphus (b. 1825), civ. asst. Trig., x, 13 n.2, 25 n.4, 35-6, 162, 413, 420, 422-3, 474 :—Joseph (1785/6-1853), Ch. Civ. Asst., GTS. [III, 491-2], viii, xi, 10, 66-7, 129, 184, 359, 402, 411, 413-4, 420, 520 :—Thos. (1818-78), civ. asst. Trig., 12 ns. 2, 3, 20 ns. 3, 4, 420, 456.
Ommanney, Edw. Lacon (1810-96), Ben. Engrs. [IV, 459-60], viii, 185, 244, 253.
O'Neill, James Roe LeGeyt, civ. asst. Trig. from 22-9-62 ; absconded 1866 ; 490.
Ootacamund, Nīlgiri Hills, 151, 290, 422, 495, 503-4, 519, 533-5, 542-3.
Opium :—Dept., 371, 419 :—eaters, 454.
Opposition to Svy., t-page, 2, 14, 33, 55, 176-8, 182, 191, 202, 208, 215-6, 219-20, 474-6, 478, 527 ; v. Disputes.
Oram, Miss E. M., g. dau. of G. H. Saxton, 523 n.7.
Ordnance :—Bd. of London, 139 n.4 :—Dept., of India, 160, 166, 425, 430-1, 501, 537 :—Dig. 166 :—SVY., Gt. Britain, 253-4, 443, 447, 502, 523, 540 :—DG., 331, 339 :—Fd. Units, 502 :—Maps, 176, 324 :—S'hampton Hdqrs, 9, 125, 141, 321, 331, 417, 496, 532, 536 n.1 :—Ireland, 254, 531 ; v. Clarke ; Colby ; James ; Mudge.
O'Reilly, Burma Svy., 196.
Organization of svy., xiv, 282, 336, 339, 342, 414, 426 ; v. administration.
Oriental :—Club, 502 n.7, 504, 531 :—Scholars, 519.
Origin, or pt. of Departure, 13, 20, 95, 120, 124-5, 128, 134, 139, 469 :—Rev. Svys., 298.
Orissa :—Climate, 462-7 :—Minor trgn., 118 :—*khalāsis*, 454 :—Trib. States, or Mahāls, 168-76, 386, 483-4, 495, 526 :—Supt., 169-70, 175 :—TRGN., GTS., 1, 22, 29, 62, 97, 105, 116 :—Topo., xiv, 367 ; v. Coast ; Cuttack ; Ganjam ; Geological ; Parties.
Ornamentation, Maps, 191, 321.
Orthography, or spelling, 187, 231, 271, 321-2 ; v. Village
O'Shaughnessy, Dr. Wm. Brooke (1809-89) ; Ben. Med. ; DG. Telegraphs, 1853-60 ; FRS. 1843 ; *DNB.* ; *DIB.* ; 140, 308.
Otto, Geo. (1826/7-48), civ. asst. Rev., 248, 433, 442.
Oudh, 473, 482, 498, 509 :—Annexed by British, 1856, 1, 405, 436 :—Govt. & Nawāb, 185, 314 :—Guards for survrs., 376 :—Rev. Svy. 6-7, 263-4, 275, 364-5, 434, 436, 451, 488, 499, 500, 509, 531, 535, 538 :—Trgn., 337 ; v. Maps.
Outram, Lt.-Gen. Sir James (1803-63), Bo. Inf. [IV, 460] ; 1st. Bart. ; *DNB.* ; *DIB.* ; xi, 374, 488, 493.
Outturn or progress, 342 :—GTS., 26, 28, 355 :—REV. SVY. :—Bengal, 251, 260, 270, 273, 280, 293-4, 301, 394 :—Punjab, 272-3, 302 :—TOPO., 4, 170-1, 176-7, 189-90, 197-8, 201, 204, 211, 313, 226, 229, 236, 282, 289-90, 368, 425, 455.
Overland Mail route, 326, 526-7.

Pabna Dist., Bengal, 245, 250, 520 ; pls. 1, 4, 16, 28.
Paces, meast. by, 195, 249, 301.
pakhāl, leather water bag, 39, 45.
Pack Animals, 371 ; v. Bullocks ; Camels ; Elephants ; Ponies.
Paddy :—Crops, 252 :—Fields, 468 ; v. Rice.
pagoda, Madras coin [I : 278 n.7 ; III, 213 n.5], 347.
Palanquin, *dhooli*, or *palki*, 371, 457-8, 460, 499, 532 ; v. Dandy.
Palfreyman (kd. 1857), civ. asst. Rev., 442, 483 n.1.
Palmer, Geo. Gidley (b. 22-1-30), engrvr., SGO., 1873-91 ; 495 536 n.1, 538-9.
Palmyras :—Longl. ser., 173, 176 :—Point, 174 ; pl. 4.
Panchannogram, Calcutta suburb., 181-3, 241.
Pangong Lake, Ladākh, 237, 239, 488-90, 506, 518 ; pl. 6.
Panoramas, or profiles, 81, 86, 146, 188, 528 :—Pīr Panjāl, 230, 239, 515 ; pl. 14 ; v. Kashmir.
Pantograph, 106, 215.
Paper :—Distortion, 127, 295, 328, 330 :—Drawing, 214, 288, 305 :—Printing, maps or stamps, 327, 329, 332-3, 502 :—Transfer, 329 :—Weighing, 307-8 ; v. Money.
Parang-La, N. Spiti, 202-3, 234 n.5, 528.
Parasnāth :—Hill, Hazāribāgh Dist., 15 :—MERDL. BKR., GTS. :—North, 15-6, 19, 29, 128 n.3, 155, 361, 373, 394, 416, 519 :—South, 22-3, 25-6, 127, 168, 172-3, 175, 382, 462.
pargana or *tāluk* ; Maps, 245, 251, 258, 263, 265-7, 269-71, 280, 297, 305-6, 313, 323-6 ; v. Boundaries ; Intermixed ; Trijunctions.
parganas :—Bengal, & NWP., 9, 179, 186, 243, 245-6251, 254, 256-7, 260, 298, 313 :—CP., 188 :—Chota Nāgpur, 184:—Kashmir, 231-3 :—Punjab, 200, 270-1, 278.
Paris, Geogl. Conference of 1875, 516, 526.
Park :—Mussoorie, 137, 531 :—Street, Calcutta, 70, 165, 351.
Parker, John, A. (1804-53), civ. asst. Rev., 255, 433, 442.
Parkes, Wm., MICE. ; Port Engr., Karāchi ; Markham (22 n.3) ; Madras, *Roorkee Papers*, v, 1876 ; 74, 194.
Parlby, Chas. Henry (1810/1-73), civ. asst. Topo., 421, 432.
Parliament, British, Reports ; 189, 253, 341, 345, 347, 447.
Partābgarh, Oudh, 263-4, 488 ; pls. 1, 4, 28.
partāl, of Rev. Svy., 245-7, 276, 278, 500 ; v. Check ; Inspection.
Parties :—GTS., xiv, 12-5, 22, 29, 34-7, 43, 50, 93, 122, 126-7, 148, 155, 336, 344-5, 361-2, 364, 368-70, 382, 402-3, 405, 452-3, 537 ; v. Bombay :—Kashmir, 5, 221 :—No. 2, Hill Series, 2, 36, 43-4, 50, 194, 210, 361, 415, 509-11, 532 :—Levelling, 76, 159, 189, 194 :—

svy., svy., Bengal, 241, 294, 298–9, 346, 364–5, 368, 433, 455 :—No. I, Peinberton, 241, 243–6, 436, 520 :—No. II, Wilson, Smyth, 241, 243, 246–51 :—No. III, Wyatt, 241–2, 251–4, 484, 543–4 :—No. IV, Sherwill, Gastrell, 186, 241–3, 254–5, 499, 529 :—NWF., 244, 263–4, 266, 272–3, 277, 298 :—Punjab, 8, 67, 194, 218, 268, 269–77, 364–5, 423, 426, 433, 436, 451–2, 541 :—Madras, 9 :—TOPO., xiv, xv, 4, 187, 189, 310, 338, 364, 367–8, 423, 426, 446–7, 541 ; v. Bengal, No. 1, Rawalpindi ; No. 2, Hdbd. ; Nos. 3 & 4 ; Ganjam & Orissa ; No. 5, Rewah, No. 6, Khāsi Hills, 489 :—No. 7, Rājputāna, 496 :—Bombay, 191–2 ; 421, 426, 429, 455 :—Madras, xiv, 127, 167 ; v. Charge ; Ganjam ; Hdbd. ; Himālāya ; Kashmir ; Madras.

parwāna, or passport, 476–7.

Paschoud, Fredk. Smith (1833–54), civ. asst. Trig., 13 n.1, 410–1, 420.

Passes, 28, 38, 45, 68, 194, 287 :—Himālayan, 202–3, 206–8, 271, 516–7, 532 :—Kashmir, 69, 224, 228, 233, 236–8, 490, 514 ; v. Banihāl ; Bāra Lāchu La ; Pir Panjāl.

Pathānkot, Punjab, 202, 205, 210, 222, 273, 514 n.1, 517.

Patiāla State, Punjab, & Mahārāja, 270, 480, 511 ; pls. 1, 16, 28.

Patna :—Bihār, 13, 18, 336, 436, 511, 529 :—City Svy., 252 :—Rev. Svy., 5, 241, 243, 434, 436, 536, 543 ; pls. 1, 4, 16, 28 :—Trib. State, Orissa, 167, 174, 176, 385.

Patterson, Wm. Henry (b. 1836), civ. asst. Rev., 275 n.2, 436.

paṭwāri, village surv. & recordkeeper, 6, 263, 268, 277–8, 292, 301–2.

Pay :—Abstracts & Bills, 361, 363, 376, 453, 455, 542 :—Advance, 406 :—Computers, 355 :—Escorts, 376, 378, 473 :—*khalāsis* & followers, 391, 452–3, 479 :—Increased rates, xv, 453, 506 :—Master, 376 :—Overtime, 338 ; v. Allces. ; Servants' Salary.

Payment of local people, 475–7, 480.

Peaks, 204, 207, 211, 253 :—Himālayan, Positions & Heights, viii, xv, 2, 10, 17–21, 64, 81–96, 118, 121, 156, 202, 318, 452, 510–1, 519, 541 :—Central Asia, 235–6 :—Kashmir Svy., 3, 5, 85, 87–9, 221–2, 224–8, 230, 232–3, 236–8, 506 :—NW. Himālaya, 35–7, 86–7, 201–3, 205, 516 :—NW. Frontier, 47, 86, 216 :—Sikkim, 19, 83, 85–6, 90–5, 147, 186, 227, 337, 541 :—Identification, 82, 84–5, 90–1, 95, 221, 227, 234 n.5, 501, 507, 519 :—Names or Symbols, 17, 82–96, 156, 510, 522 :—Occupation as stn., 157, 222, 230, 235, 340, 505 :—SG.'s interest, 10, 65, 81, 83–7, 90–5, 337, 523 ; NE. :—Visibility, 84–5, 223 v. ; Comps ; Everest ; Heights ; Himālaya ; K_2 ; Longl. ; Nepāl. Refraction ; Snow ; Vertical angles.

Pegs, or wooden pickets, 77, 84.

Pegu Prov., Lower Burma :—Annexation by British, 1853, 1, 5, 194–5, 308 :—Ch. Comnr. & Govt., 195, 197, 199, 497–8 :—Ex-Engr., 423 n.2 :—Maps, vii, 196–9, 824, 497–8 :—Roads, 498 :—Tel. Dept., 141, 395, 497 :—Topo. Svy., 1853–67, 5, 165, 195–9, 244, 282–3, 285, 296, 384, 425, 430–1, 447, 490, 492, 497–8, 531, 536, 543.

Pearson, John Richd. (1833–1910) ; Ben. Art., 1852–66 : 197.

Pemberton, H. L., and bro., James Stuart (b. 1843), both civ. asst. Rev., 267 n.6, 442, 520 :—Robt. Boileau (1799–1840), Ben. Inf. [III, 493–4], vii, 195, 311.

Penalty for premature resgn., 403, 450.

Penang I., PWI., Malaya, 144, 544.

Pendulum :—apparatus, 377, 490–1, 540 :—Obsns., 137, 380, 490–1, 503, 540.

Penganga R., Berār, 179, 485–6 ; pls. 1, 28.

Peninsula of India, South, xiii, 319, 492.

Penny, Fredk., civ. asst. Trig., 28 n.3, 420, 465.

Pensions, 29, 226, 343, 353–4, 356–7, 425, 434, 510, 520, 522 :—commuting of, 527 :—*khalāsis*, 454–5 :—Widows & children, 491, 508.

Perambulators, 14, 160–2, 166, 169, 184–5, 288, 363, 540 :—Everest pattern, 160–1 :—Madras, 161–2 :—Measts., 5, 18, 25, 52, 104, 119–20 :—Traverse, 174, 184, 119, 215, 217, 281, 288, 303.

Permanent :—Est., 358 :—Settlement, 6, 244–6, 292–4, 300.

Permien :—Dan., sch. mr., Allahābād, 520 :—Thos. Hanbury, civ. asst. Rev., 270 n.5, 433, 442.

Persia, 194, 500, 510 :—mil. expn., 531 :—Teheran, 540.

Persian :—Geographers, 240 :—Gulf, 59 :—Language or script, 113, 365, 481, 526–7 :—Nationals, 215, 447.

Peshāwar, 4, 36–7, 85–6, 118, 146, 214–7, 220, 227, 407, 446, 448, 475, 482, 488, 511, 515 :—Compr., 215 :—Fever, 492 :—Map, 317 :—Position & Height, 215, 217, 317 :—Rev. Svy., 508–9 :—SG.'s Tour, 36, 42, 165, 202, 215, 287, 316, 337, 343, 509, 541 :—Trgn., 35–7, 215–6, 296, 317, 422, 475 :—Walker's svy., 1849–52, 36–7, 47, 209, 214–8, 232, 282, 286, 361, 363, 381, 387, 447–8, 474, 498, 511, 539 ; pls. 1, 3, 5, 16, 28.

Peter, Samuel, civ. asst. Topo., Pegu, 447.

Petermann, Dr. Aug. (1822–78), cartr. of Gotha, Germany, FRGS. ; *IO Cat.* (530) ; 540.

Pew, John Geo. (b. 1839), civ. asst. Topo., 176 n.6, 432.

Peyton, James (b. 1831), civ. asst. Topo., 178, 202–3, 205–8, 239, 318, 414, 421, 423, 428, 432, 520.

Pharoah & Co., booksellers, Madras, 319.

Phayre, Lt.-Gen. Sir Arthur Purves (1812–85), Ben. Inf., Hodson, III (516–7) ; GCMG. ; KCSI. ; CB. ; *DNB.* ; *DIB.* ; Comnr., Arakan, 1849 ; Pegu, 1852 ; Ch. Comnr., 1862–7 ; 544.

Phillips, Anthony (b. 1824), 244 n.6, 250, 442 :—& bro., S, both civ. asst. Rev., 242.

Phil. Trans., RS., 9 n.6, 136, 520.

Photo. group, Calcutta, 1861, 340 n.3, 515, 517, 536, 539, 541 ; pls. 21, 23.

Photographic :—Branch, SGO., 331 :—Apparatus, 331 :—Soc. of London, 535.

Photo :—Lithography, 9, 141–2, 331 :—Zinco Dehra Dūn, 9, 176, 208, 238 n.10, 254 n.5, 319, 331, 417, 489, 502, 507, 513 :—Poona, 445.

Photographers, amateur, 141–2, 331, 419, 513, 517.

Photography, 1, 159, 235, 527 :—of Maps, 141–2, 239, 495, 513, 517–8.

Physical :—ground features, 211 :—Geography, 145, 187, 528–9, 531.

Pickard, James (b. 1831/2), civ. asst. Rev., 433, 442.

Pickell, Henry (b. 1822–3), civ. asst. Rev., 433, 442.

Piddington, Comdr., Henry (1797–1858), Merch. Mar. ; Curator, ASB., Calcutta, Markham (36–7), *DIB.* ; 143–4.

Pierce, Richd. Wm. (b. 1830), civ. asst. Trig., 35 n.2, 38 n.4, 99, 200 n.2, 405, 420, 422.

Piles :—physical ailment, 206, 461, 464 :—foundations, 74, 206, 212, 222–3, 409, 469, 477 :—Tower Stn., 106–12, 270 :—Topo. Stn., 212, 287, 363, 406 ; v. Masonry.

Pilibhīt, Rhilkd. 16, 18, 21 :—Rev. & Town Svy., 258, 261 ; pls. 1, 3, 28.

Pillars, stone or brick :—Base-line, 19, 42–3 :—Bdy., 19, 188, 201, 210, 248, 252–3, 255, 260–1, 263–4 :—GTS. stns., 30, 39, 41, 71, 106, 108–13, 120, 188, 174, 218, 222, :—Isolated from observn., 12, 105–6, 108, 114, 222–3 :—rev. svy., connection, 52, 216, 295 :—tidal conn, 74 ; v. Masonry.

Pilots, Hooghly R., 419, 427 n.4, 431.

Pine tree, viii, 222, 543.

Pioneer, newspaper, Allahābād, 369 n.3, 508 n.4, 512 n.2.

Pipal trees, *ficus religiosa*, 23, 413, 478.

Pīr Panjāl range, W. Himālaya, 3, 5, 36–7, 87, 221, 224, 226–7, 229–30, 239, 286, 454, 490, 505, 514–5, 518 :—Pass, 224, 226, 228, 234, 480 n.5, 514 ; pls. 6, 18 ; v. Panoramas.

Plains, or flat country :—Bengal & Bihār, 64, 67, 94, 281, 303 :—Punjab & Sind, 4, 36, 40, 45–7, 68, 75, 214, 217, 235, 239, 275, 423 :—Traversed by GTS., 26, 29, 49, 57, 61, 64, 67, 78, 100–1, 102–4, 107–9, 337, 393, 472 :—flat & wooded, 22, 120, 178, 175, 190, 195–6, 260, 468.

Planetable :—Inst., 120, 158, 165–6, 203, 206–363, 455 :—mounting of, 229, 288 :—sections, 190, 206, 212, 214, 227, 234, 282, 489 n.7 368, 385 :—Rev. Svy., 8, 267–8, 277–8, 280, 293, 302 :—SVY. System, 4, 170–1, 200–1, 208, 281–2–3, 288–90, 385, 406, 424, 427, 447, 517, 525 :—sketch by trptrs., 33, 120 :—SVY. : Himālaya 86, 201–8, 418, 422–3, 429, 516–7 :—Hyōbd., 485 :—Kashmir, 3, 89, 225–7–8–34, 236, 368, 488, 493, 506–7, 515 :—Orissa, 167–8, 173–5, 525–6 :—Punjab, 210–3, 215–6, 218.

Planetablers, 179, 189–90, 286–7 :—Himālaya, 4, 201, 426, 428 :—Kashmīr, 225–7, 234–6, 495, 488–9, 511, 518 :—Orissa, 169, 173–8, 176, 367, 421, 426 :—Punjab, 210, 290, 387, 416, 421, 427, 446 :—Indian, 447.

Plaster, cement, lime mortar, or mud, 106, 111–2, 212, 222–3, 409, 469, 477 :—Tower Stn., 106–12, 270 :—Topo. Stn., 212, 287, 363, 406 ; v. Masonry.

Platforms :—GTS. :—in Hills, 12, 27, 48, 56, 59, 98–101, 113, 130, 222–3, 409, 469, 477 :—Tower Stn., 106–12, 270 :—Topo. Stn., 212, 287, 363, 406 ; v. Masonry.

Platts, John Thompson, civ. asst. Topo., 210–1, 423–4, 432–3 :—SVY.

Plotting :—traverses, 196, 450 :—trig. pts., 237–8, 285, 368, 507.

Plumbline ; or plummet ; 107, 109–10, 160 ; v. Deflection.

Plunder, 85, 47, 177, 461, 474, 484–5.

Pogson, Norman Robt. (1829–91), Mad. Astr., 1861–91 : GIR ; RAS. (*mn.*), LII, 1891 (235), 534, 540.

Points, Trig. :—for detail svy., 101, 135, 171, 190, 192, 205, 210, 213, 224, 227–8, 230, 232, 234, 281–3, 290, 423, 425, 506 :—Secondary trgn., 99, 119–21, 167, 186, 227, 235–7, 295, 297, 409, 449 :—spacing, 210, 216, 225, 227, 230–1, 282, 289 :—for Rev. Svys., 19, 120, 268, 472, 519 ; v. Plotting.

Poison, 505, 508.

Pole Star, *polaris*, 122, 286, 507.

Police :—15, 257, 377–8 :—Armed, or *paiks*, *sebundis*, 178, 376 n.1, 527 :—Dept., 190 :—Divs., Bengal, 218, 243, 500, 517 ; v. *thanas* :—Officers, 435, 444, 479 :—Stations, or *chōkis*, 170, 184, 259 ; v. Guards.

poligars, of S. India [II, 473], 478.

Political :—Agents & Offrs. (PA.), 63, 183, 191, 230, 310, 464, 469–70, 476, 489, 509, 478, 494 :—Authorities, 369, 427, 526 :—Dept., 267 n.4, 270, 512 :—Mission, 217, 508 :—Policy, 210, 217, 201, 310, 507.

Pollexfen, John James (1825–60), Bo. Inf. ; DAQMG., 1849 ; FRGS., 1855, 192.

Pollock, FM. Sir Geo. (1786–1852) ; Ben. Art., Hodson, III (548) ; 1st Bart. 1872 ; Khyber, 1842 : GCSI., GCB. ; *DNB.* ; *DIB.* ; 492, 536—medal, Addiscombe, RMA., 490, 503, 518, 543.

Pollok, Fitzwilliam Thos. (b., India, 1832), Mad. Inf., 1848–78, FRGS., 1855 ; 196.

Polygon : of triangles, 14–5, 19, 23–4, 28, 32, 37–9, 44, 47, 51, 56–7, 59, 97–102, 221, 225, 232 :—Comps., 122, 128 :—of levelling, 76.

Ponies, or *tattus* :—pack, 362, 371, 373, 481 :—riding, 429 ; v. Horses.

Poona, Deccan, 59, 101, 275–6, 371, 416, 500, 523 :—Rev. Svy., 396, 494, 498, 511, 533 ; pls. 1, 3, 28.

Population :—Dense, 40, 214, 236, 279, 462, 473 :—Density estimated 257, 346 :—Enumerating, 168, 192 :—Increase, 256 :—Sparse, 32, 40, 176, 289, 375, 479.

Porbander, Kāthiāwār, 72, 74 ; pls. 1, 3, 28.

Porter :— drink 183 :—bearers or carriers, 38–40, 149–50, 162, 174, 206, 225, 363, 371, 430, 454–5, 463, 476–7, 479.

Portraits, 488–541, *passim* ; pls. 21–7.

Portuguese, 57–8 ; v. Diu ; Goa.

Postage Stamps, 165, 348, 357 :—Printed, SGO., Calcutta (OBO., Lib. Q.) 52 ; 9, 329, 332–5, 348–9, 357, 537.

Postal :—Charges, 452 :—Mail Service, 176, 228, 236, 447, 482–3, 491 :—Maps, 315 :—Staff, 39, 473, 491 ; v. *Dak*.

Post :—Master, 77 :—Master-General (PMG.), 452, 491 :—Office, Calcutta, 452 :—mortem, 508.

Potenger, Geo. (b. c., 1820), dmn. SGO., Calcutta, 354, 360.

Pots :—brass, cooking, 474 :—earthen, or *gharas*, 212, 260.

Pottinger :—Eldred (1811–43), Bo. Art. [IV, 461], 448 :—Sir Henry (1789–1856), Bo. Inf. [II, 437] ; Govr. of Madras, 1847–54, 525 n.8.

Poultry, 168, 183.

Powder :—Factory, 256 ; v. Ishāpore :—Magazine, 484.

Praise, 395, 536, 542.

Prayers, 252, 473.

Precipice, 170, 203–4, 206–7, 224, 226, 429, 454, 467, 514.

Presents, diplomatic, 216–9, 507, 543.

Press ; v. Lithographic ; Newspapers ; Photo-Zinco ; Printing.

Pressmen, or litho-printers, 328 n.4, 333, 357.

Prices, *bāzār* ; v. *mirick*, 362, 478–9.

Principal :—of Coll. or Instn., 512, 543 :—Stns. & Triangles, GTS., xiv, 2, 20–101 *passim*, 118–186, *passim*, 200–95, *passim*, 320, 393, 417, 422, 472, 485, 513, 525, 540.

Pringle, John Robt. (b. 1819–20), & Walter Hovenden (b. c., 1822), bros., both civ. asstS. Rev., 244 n.6, 275, 433, 442.

Pinsep:—James (1799–1840), Assay Master, Calcutta Mint [III, 495], *DNB.*; *DIB.*, 307:—Henry Thoby (1792–1878), BCS. [IV, 489], *DNB.*; *DIB.*, 353:—Thos. (1800–30), Ben. Engrs. III, 495–6], Conolly (86/120); vi, 248–9.
Printing:—Letter-press, 123, 329:—Map, lettering by hand, 171, 239, 283:—by Type, 321; *v.* Litho.; Map.
Prisoners, 35, 186, 423, 473–4, 507, 538.
Private:—Map-printing, 315:—Property, 174, 182, 248; *v.* Servants.
Professional:—Advice, 338:—Control, 172, 198, 295, 338, 350, 405:—*Papers, S of I.* (*PP*), xxvii, 66, 137:—Qualifications, 178, 526:—Rev. Svy., 6, 8, 241–2, 245–8, 272, 293, 455:—Survrs., 95, 147, 260, 293–5, 301, 365.
Professor of Svy., 257, 397, 529, 543.
Programme of Svy., xiv, xv, 6, 175.
Progress:—Reports, 125, 213, 292, 346, 364; *v.* Outturn.
Projection:—*Atlas of India*, 311, 540:—Maps, 292, 507:—Rev. Svys., 298–9:—Tables, 123, 125, 308, 355, 522, 540.
Prome, Burma, 141, 196, 198 n.4, 495, 543; pls. 1, 16.
Promotion:—DEPTL., 157, 387–9, 429, 434, 507, 510, 525:—GTS., 381–2, 408–9, 417, 502, 506, 516, 525:—Civ. Assts., 427, 506–7:—Rev. Svy., assts., 350:—Topo. assts., mil., 513:—MIL., 3, 28, 177, 363, 381–2, 384, 489, 502, 527, 533, 537; *v.* Major; Mil. Rank.
Property:—landed, svy. of 249, 282:—Private Sale, 371.
Protraction of svy., 198, 450.
Prowett (or Pruett?), of NWP. Canals, 313 n.3.
Public Works Dept. (PWD), 330, 375, 502, 534, 543:—Competition for Staff, 403, 407, 424, 493:—Salaries, 407:—Assam, 312:—Bengal, 142, 165, 185, 299 330, 353–4, 387–8, 397, 490, 498, 541:—Bombay, 494:—Burma, 447:—CP., 492, 494:—Madras, 538:—Punjab, 423 n.2, 508, 511, 532, 535:—Sind, 76, 494, 528.
Publications:—Govt. Books 323:—Deptl. Papers & Reports, 122, 125, 137, 345:—Maps, 306, 348:—Svy. results, 91–2, 95–6:—Scientific, 139, 146.
Puckle, F. C. & H. W., pro. bros., civ. Rev. Survrs., Madras, 280, 445.
Puissant, Col. Louis (1769–1843), French Geodst. [III, 530], 339:—*Traité de Géodesie*, 92, 522.
pujah, Hindu holidays, 334.
Pullan, Ayrton (1835/6–91), Ben. SC., 1856–86; appd. Kashmir Svy., Jan. 1863; on Topo. svys. till furl. 1–4–91; d. 30th April, England, 237 n.3.
Pünch, Jammoo & Kashmir, 220 n.3, 226, 228–9, 231, 518; pls. 6, 13.
Punishment, 354, 377, 390; *v.* Penalty.
Punjab, 1, 2, 7, 34–7, 200–14, 308, 316–7, 343, 387–8, 539:—Army of 1848–9, 504:—British occupation, 1, 7, 34, 272, 337, 341, 363, 380, 405:—Ch. Comnr.; *v.* Comnr.:—Comn., 396, 491:—Govt.; 67, 141, 238–9, 349, 387, 397, 472, 507–8, 511; *v.* Govr.:—Inf. Regts., 492, 499–500:—Local People, 539:—Rev. Svys., 1, 3, 7, 50, 52, 119, 125, 131, 200, 210–4, 217–8, 264, 268–75, 294, 298, 301–2, 310, 351, 391, 396–7, 433, 435–6, 499–500, 509, 536; *v.* Parties:—Topo. Svys., xiv, 1, 4–5, 9, 200–17, 274, 282, 286–7, 289, 337, 387–8, 423–5, 524, *v.* Himâlaya Mts.; Pupils, & Assts., 422–6:—Trgn., GTS., xiv, 1, 13, 18, 34–7, 154, 337, 361, 415, 417, 427, 501; *v.* Canals; Maps; PWD; Râwalpindi; Towers.
Purdon, Wm. H. (d. 15–1–82),; Lahore; PWD., Punjab, 1850–76, FRGS. 1859; *RGS. Progs.*, IV, 1859, (31–3), paper on Kashmir; Kur. letters, I (88), 11–11–69; 144.
Purge, or *jalâp*, medical, 457–60.
Puri, or Jagannath, Orissa, 22, 26, 173, 326, 367, 386, 466:—Collr., 174:—Dist. Maps, 311, 326:—Rev. Svy., 296, 536; pls. 1, 3, 16, 28.
Purnea, Bihâr:—Dist., 2, 19, 21, 118, 336, 452, 502, 519, 523, 541:—Map, 313:—Rev. Svy., 5–6, 241, 244–5, 296, 303, 313–4, 336, 364, 370, 434, 439, 455, 520:—Town, 142, 337–8, 509; pls. 1, 3, 4, 16, 28.

Quadrilateral:—trgn. figure, 32, 34, 38–9, 47, 59, 97–102, 119, 128, 221–2, 225:—Sections of GTS. lay-out, 540; *v.* NE., NW., SE.
Qualification tests & reports, 402, 405, 421.
Quartermaster-General:—Bengal, 125, 217, 310 315–6, 339, 388:—Deptt., or Office, 189–90, 325, 328, 357, 386, 388:—Offrs., AQMG., etc., 5, 190, 225, 227, 229, 309–10, 315, 326, 488, 490, 550, 511, 537:—Bombay, 192–3, 315, 490:—Madras, 319, 448.
Quicksands, 38, 255–6.
Quinine [II, 360], 216, 255, 459–60, 462, 464–5, 512.

Rae Bareli, NWP., 11, 156, 184, 488, 541; pls. 1, 4, 28.
Rahun merdl. ser., GTS., 3, 37 49–51, 63, 80, 138, 153, 345, 361, 408, 415–6, 423, 428 480, 482, 484, 509–11, 513; pls. 3, 5.
Raids, tribal, 151, 218, 377.
Railways, 1, 370, 374–5:—Bench-marks, 79:—Admin., 524, 532, 538:—Comm. Calcutta, 1845–6, 374:—Construction, 277, 311, 324, 373, 470:—Demand for Maps, 182, 311, 323:—East-Indian, 165:—Competition for Svy. Staff, 403–4, 418, 420, 424, 437, 439–40, 454:—of England, 523, 531:—Station, 488:—Travel by, 522, 542–3; *v.* Engrs.
Rain:—fall, quantity, 25, 45, 51, 59, 82, 85, 107, 110, 130, 206, 229, 365, 467:—falling, 17, 100, 198, 458, 514, 534–5, 543:—lack, or drought, 212:—Storm, 491.
Rains, *v.* Monsoon.
Râjahmundry, Madras:—Topo. Svy., 490:—Coast Ser., GTS., 29:—Rev. Svy., 279–80; p. 28.
Râjaori, Jammu, 220, 514; pl. 5.
Râjkot, Kâthiâwâr, 191, 500.
Râjmahâl, Bihâr, 142:—Hills, 244, 254, 256, 529, 535:—Rev. Svy., 434 529; pls. 1, 4, 28.
Râjpipla State, Gujarât, 3. 55, 192, 467; pls. 1, 28.
Râjput States & Chiefs, 50, 191.
Râjputâna, 2, 6, 38, 190–1, 379, 452–3, 498, 533–4:—AOG., 266, 500:—Fd. Force., 1858–9, 500:—Forts, 400:—Maps, 315–6:—Rev. Svy., 265–6, 495, 500, 536, 536–9:—Topo. Svy., 1863–70, 428, 496:—trgn., XIV, 38–41, 366, 406, 415, 523, 533; pls. 1, 5, 16, 28; *v.* Desert.
Râjshâhi, Bengal—Climate, 452:—Maps, 312:—Rev. Svy., 241–2, 245, 250, 253, 520; pl. 16.
ramazân, Muhdn. month of fast, 333.
Râmchand (d. 19–1–87), leveller, 76–80, 446, 448.
Râm Dayal De, sub-asst. GTS. [IV, 385], 418, 501.
Râm Din (d. 1856), dafadar, 226, 418.
Râmgarh, Chota Nâgpur, 535:—Batt., 184:—pls. 1, 16, 28.
Râmpur, Upper Sutlej, 200–3, 237, 430, 479; pls. 1, 4, 5, 28.
Ramsay, Gen. Geo. (1813–87), Ben. Inf., Hodson, III (509–10). Resdt., Nepâl, 1853–67; 318:—Gen. Sir Henry (1816–93), Ben. Inf., Hodson, III (601); KCSI., CB., bro. of 12th Earl of Dalhousie; *DIB.*; served in Kumaun & Garhwâl from 1840; Comnr. Kumaun, 1856–84; 262.
Ramsden, Jesse (1735–1800), inst. maker [III, 530], FRS.; *DNB.*, 150, 154.
Ranbir Singh, son of Gulab Singh (d. 1885), Mâhârâja of Kashmir 1857–85; 5, 141, 230, 238–9, 515.
Ranchi, Chota Nâgpur, 176, 184, 480–1, 485; pls. 3, 4.
Ranghir merdl. ser. GTS., 1, 16, 67, 103, 107, 125, 309, 366, 415, 523, 54; pls. 3, 4.
Rangoon, Burma, 1, 141, 194–7, 199, 384, 395, 436, 497, 538, 543:—Longde., 196:—Map, 197, 538:—River, 197; pl. 1.
Rangpur, N. Bengal; Rev., Svy., 241, 243, 245–6; 314, 520; pls. 1, 4, 16, 28.
Râniganj, Bengal coalfields, 23, 374; pls. 1, 28.
Ranjit Singh, of Lahore (1780–1839) [III, 530], ix, 200, 220.
Ratnâgiri, Dist., W. Coast, rev. svy., 275, 511; pls. 3.
Râvi R., Punjab, 4, 7, 37, 52, 113, 200–2, 205, 210, 220, 222, 271–3, 296, 316, 364, 370, 410, 524, 496, 501, 513, 516, 534.
Ravines, 57, 190, 211, 215, 230, 262, 265, 289, 291.
Râwalpindi, Punjab, 4, 34, 77, 79 n.1, 146, 210–3, 219, 221, 224, 317, 337, 429, 448, 482, 492, 539–50:—Cants. 213:—Dist., 4, 79, 274:—Robinson's Svy., 4, 7, 44, 189, 209–14, 217, 221, 274, 284–7, 317, 353, 363, 375, 377, 387, 389, 403, 414, 423–4, 427–8, 442, 518, 524–5:—Maps, 4, 144, 199, 289–90, 317–8:—Rev. Svy. not required, 211–2, 274, 284–5:—Scale of svy., 289.
Rays of GTS. trgn.:—visibility, 102, 111:—Traces, 12, 14–5, 24–6, 57, 60, 98–9, 103–5, 108, 119–20, 157, 160, 184, 192, 282, 291, 373, 409, 525:—Clearing of, 12, 15, 17–8, 23, 25–6, 30, 48–50, 58, 60, 103–4, 111, 174, 409, 476:—Length, 118:—to Snow Peaks, 93; *v.* Grazing; Line-Clearing; Triangles.
Read, Col. Alex. (*c.* 1851–1904), Mad. Inf. [1: 369], 7, 288.
Rebellion, 525, 529; *v.* Santâl Campaign.
Rebels, or insurgents, 32, 35 157, 170, 179, 279, 374, 413, 427; *v.* Mutineers.
Rebuke, or reprimand:—by Govt., 507–8, 512:—by SG., 367, 390–5, 497, 527.
Recess:—Duties, 50, 90, 122, 126–7, 290, 333, 446:—Leave, 452–3:—Qrs., 219, 18, 26, 29–31, 41, 48, 56, 59, 122, 163, 176, 184, 211, 213, 21, 9, 262, 264, 267, 314, 368–70, 392, 466, 488, 495–6, 498, 509, 511, 516, 524, 535:—Season, 290, 365–8, 398; *v.* Mssrs.
Rech/na *doâb*, Ravi–Chenab; Rev. Svy., 7, 52, 270, 273–4, 277, 296, 436, 491–2, 500, 510–1, 530; pl. 16.
Reconnaissance (recce.):—Sketch-svy., 4, 167, 209:—GTS. trgn. 15, 84, 98, 114, 121, 222, 228, 232, 493:—Topo. Svy., 216–7, 223, 233–4; *v.* Approx. series.
Recorders, Levelling, 78, 446:—Rev. Svy., 8, 211.
Record-keeper, 323.
Recording of obsns.; GTS. 114, 116–7, 402, 409, 491, 495:—Topo. 285.
Records:—Corr. 346, 352, 376–7:—Historical, 341:—Prof., 323, 346, 351–2, 369, 372, 482:—Rev. Svy., 7, 266–7, 270, 305, 325, 352, 396, 483, 488, 509:—Destruction, or loss, 266, 305, 322–3, 346, 378, 483:—Security, 333–4, 482.
Recruits:—Rev. Svy., 433–4, 436–7:—Topo. Svy., 422, 425–6.
Red:—Ink, 330:—Tape, 291.
Rees, Vincent Louis (1794–1862), Compr. [IV, 462], viii, x, 139–40, 354, 356, 522.
Referring Marks, 24, 84, 173.
Refraction, 41, 53, 61–6, 69, 117, 337, 539, 541–2:—Co-efficient, 65, 81–2, 88, 90–4:—Experiments, 66, 75, 84, 90:—Lateral, 102, 117:—Laws, xv, xvi, 64–5, 90, 522:—Maxm., 64, 111:—Minm., time of, 24, 60, 62–5, 80, 82, 84, 88, 90, 111, 212, 221 287:—to Snow Peaks, 65, 81–2, 84–8, 90–4, 522, 541:—Tables, 124:—Vagaries of, 2–3, 57, 60, 62–5, 221, 539.
Regimental:—Duty, 89, 197, 379, 381, 488, 491, 494, 497, 505:—Command, 339; *v.* Military.
Register of Lands, 280, 292.
Registrar (Regtr), SG.'s confidential clerk, 322–3, 338, 341–1, 359, 372, 521, 542–3.
Regulations:—Bengal Rev. Svy., 429:—Survrs., 453, 459:—Pay & Allces., 398, 453.
Reid, Henry Mountford (1817–66), BCS. 1836–63; 242.
Rejection of:—Svy., 241, 247, 304:—Obsns., 82, 91, 100, 114.
Religious:—Ceremonies, 51–2:—Fanatics, 470, 472–3.
Remusat, Jean Pierre Abel (1788–1832), French Orientalist; *Ency Brit.*, 240.
Rennell, Maj. James (1742–1830), Ben. Engrs. [1: 360–78]; *DNB.*; *DIB.*; xlii, xvi, 81, 240.
Rennie, Comdr., IN., Irrawaddy R., *IO. Cal.* (120); 73.
Renny-Tallyour, Col. Thos. Francis Bruce (1863–1937), RE., S of I. 1888–1939; Conolly (58/1702); *REJ.*, Sept. 1937 (291); 522.
Rent:—House, 351–2, 411, 508:—free Lands, 280, 292.
Reports:—Annual, xv:—GENERAL:—GTS., 121–2, 202, 345:—Rev. Svy., 350–1:—Topo. 198–9, 214, 233, 290, 345, 527:—PROF., GTS., MS., (TS), 86, 92, 116, 121–2, 126–8, 134–5, 415, 417:—Explorers, 507:—Statistical & Geogl., 529.
Resection, or 3-point problem:—by PT., 217, 282, 289:—by Theodolite, 297.
Residency, political:—Hdbd., 179:—Ladâkh, 508; *v.* Lucknow.
Residents:—Indore, 188, 315:—Lahore, 34, 388, 492; *v.* Bhopâl; Gwalior; Hdbd.; Lucknow; Nepâl.

Resignations :—GTS., 12, 27, 30–1, 188, 234, 288, 342, 879, 892, 895, 403–4, 410–4, 416, 461–2, 497, 601, 604, 607, 522–3 :—Hdqr. Offices, 353–6 ;—Rev. Svy., 435, 437–8, 452, 500 :—Topo. Svy.; 178, 211, 424, 428.
Re-survey :—Rev. Svy., 241, 243, 246–7, 249, 255, 258, 263, 267, 271, 276, 304, 385, 538 :—Topo., 197 :—Town, 181 ; v. Revision.
Retirement, 10, 140, 177, 257, 379–81, 451–6, 428.
Retrenchment, 5, 244, 408, 436 ; v. Economy.
Returns, periodical, 346, 364, 378, 446.
Revenue :—Assessment, 242, 246, 258, 292, 299, 471 :—Offrs., xii; 194, 275, 292–3, 300–5 :—DEPT. Bengal, 347 :—Bombay, 530 —Madras, 180 :—Punjab, 260 :—Law, 299 ; v. Comnrs. ; Land ; Settmt.
Revenue Survrs. 4-page :—Allces., 337–9 :—Bengal, 5–6, 107–8, 184–5, 242, 245, 281, 283–5, 296, 305, 321, 348–50, 364–5, 391, 393–8, 400, 497–9, 519–20, 525, 528–9, 531, 537–8, 543–4 :—Bombay, 268, 275, 297, 398, 400–1, 488, 495, 498, 500, 510–1 :—CP., 6, 268, 397–8, 400, 492, 526, 538–9, 543 :—Madras, 8–9, 279–80, 401, 495, 503, 519, 521 :—NWP. or Upper India, 67, 185, 260, 397, 400, 413 n.4, 433, 456, 494–5, 500, 504–5, 530–1, 535, 538 :—Punjab, 7, 68, 131, 201, 217, 284–5, 296, 350, 396–8, 477, 488, 491–2 :—Prof., co-operaton with Civil Supt., 242, 263, 293, 476 :—Combined duties, 243, 248, 250–1, 301 ; v. Assts. ; Bihār ; Civil ; Indian ; Nominal Rolls ; Prof. ; Sub-Assts. Supt.
Revenue Svy. :—Branch, Deptl., 341, 428–9, 537 :—Hdqrs., Office, 181, 339, 352–4, 358, 505 :—Ajmer, 56, 265–6, 494, 539 :—Arakan, 243–4, 298, 351 :—Assam, 1, 242 :—Bengal, LP., xiv, xv 1, 5–6, 119, 164 n.1, 241–57, 293–306, 309–11, 337, 349–51, 395–8, 414, 536 :—Berār, 268, 444–5, 497, 510, Bihār, 1 :—Bombay, xv, 1, 7–8, 275–6, 280, 292–3, 303, 338, 396, 434 :—CI., 1, 6, 143, 267–8 :—Derajāt, 4, 47, 217–8, 274, 508 :—Ladākh, 508 :—Madras, xv, 1, 8–9, 179–80, 279–80, 293, 338, 411 :—Orissa, 23, 169, 174–5 :—Pegu, 197–8, 298 ; v. Ajmer ; Chota Nāgpur ; Cis. Sutlej ; CP. ; Dacca ; Deccan ; Delhi ; Malaya ; NWP. ; Nilgiri Hills ; Oudh ; Punjab ; Purnea ; Rājputāna ; Rohilkhand ; Sind ; Tirhut.
Revenue Svys. :—Admin. & Policy, xiii, 1, 8, 10, 284–5, 336, 338, 345 :—Closed down, 1842, 433–4 :—CONN. :—to GTS., xiv, 8, 20, 23, 26, 37, 47, 50–2, 56, 96, 118–20, 131, 341, 472 ; v. GTS., Control :—to Topo., 200 :—CONTROL by DSG, xiv xv, 338, 349–51 :—by SG., 280, 297, 336, 338, 342 n.4, 349, 388, 391, 536–7, 542, n.4 :—MAPS :—Bengal, 9, 119, 245, 251, 256–7, 305–6, 312–3, 321, 325–7, 337, 352 :—Bombay, 276 :—Madras, 9 :—NWP., 119, 165, 267–70, 293, 295, 297, 305–6, 314, 337, 348, 352, 483 :—Punjab, 119, 204, 284–5, 297, 302, 305, 310, 316, 318, 350, 509 : Svy. of topo. detail 289 ; r. DSG. ; Cost Rates ; Faulty ; Re-survey ; Revision ; Settlement. ; Village.
Revision :—GTS. obsns., 16, 21, 25, 30, 49, 54, 56, 86, 100, 129 :—Rev. Svy. 246, 271–2, 275, 299, 396, 436 :—Topo., 212, 391 ; v. Re-survey.
Revolver, or pistol, 218, 484.
Rewah, Baghelkhand, 11–2, 189 :—Topo. svy., 389, 428, 496, 518 ; pls. 13, 16, 28.
Reward, or gratuity, 183, 354, 446 n.3, 454, 507, 539.
Reynolds :—Lt. Gen. Chas. (1756/7–1819), Bo. Inf. [I : 378–80 ; II, 438–9], SG. Bombay, 1796–1807, xiii, 81, 191, 315 :—Wm. Henry (1843–1911), civ. asst. Rev. ; IPS. Consvr. ; FRGS. ; 443.
Rheumatism 32, 209.
Rice, 32, 141, 373, 465–6 :—eaters, 454 ; v. Paddy.
Richardson, Richd. (c 1830–57), civ. asst. Topo., 172–3, 422, 428, 432.
Rind, Dr. Nathl. (1793–1840) ; Ben. Med. [III, 298 n.6 ; IV, 464], 325, 357 :—Capt. J. N. (1800–42), Ben. Inf. [IV, 463–4], xi.
Ripley, Col. Fredk. Wm. (1823–75), Ben. Inf., 1841–70 ; 195.
River :—Banks, 107, 185, 256, 260 :—Communications, 185, 369–70, 372 —Crossings, 245, 256, 294, 372 :—Islands, 256 :—Journeys, 338, 341, 372, 509, 513, 541 :—Soundings, 185 :—Survr. 15, 25, 71, 196 :—Transport, 44, 370, 372 ; v. Boats.
Riverain :—Areas, 48 :—Cultivation, 279 :—Svys., 68 n.1, 261–2, 271, 297.
Rivers, xiii :—as Boundaries, 294 :—Erosion, 296 :—in Flood, 14 :—Navigable, xi, 185, 228, 231, 490, 519, 532 :—Obstacles to trgn., 46–9, 102, 104 :—Shifting, 107, 252, 257, 271, 312, 468 :—of Assam, 373 :—Bengal, 255–6, 294 :—Bihār, 13 :—Himālaya, 220, 517 :—Orissa, 25, 174 :—Punjab, 7, 52, 417 :—Survd., 2, 98, 118, 184–5, 189, 196–7, 215 246, 258, 263 :—both banks, 245, 252, 262, 264, 294 :—Trgn., 201, 252, 255–6, 296, 423 ; v. Boats.
Road :—Agra–Bombay, ix, 126, 309, 494 :—Decca–Arakan, 524 n.4 :—Grand Trunk, 79, 185, 212, 252, 314–5, 321, 353, 374, 493, 531, 535—Maps, 309 :—Peshāwar–Kohāt, 214 :—Simla–Tibet, 430.
Roads :—Bad, 20—Burma, 498 :—Construction of 194, 267, 512 :—Hill, 201–2, 224, 429–30, 513, 524 :—Himālayan 512 :—Kashmīr, 224, 226 :—Lack of, 28, 204, 430, 504 :—Levelling along, 77 :—Metalled 161 :—Military, 218 :—Svy. of, 167, 169, 184, 189, 193, 211, 24, 89–5 252, 267, 272, 288, 313 :—fit for Theodolites, 36, 38, 47, 149, 222 :—of Sind, 371 :—Windings, of 195 ; v. Pegu.
Robbers & Dacoits, 170, 194, 377–8, 449, 500.
Robbery, 177–8, 191, 332, 364, 374, 377–8 ; v. Theft.
Roberts, Prof. Edw. (1845–1933), FRAS. 1872 ; *RAS.* (*mn*), 94. 1933–4 (284) ; *Ency Brit.*, sn. TIDE ; inventor of Tide-predicting machine, 540.
Robinson, inst.-maker [IV, 139–40], 299 :—Maj. Edw Innes (1811–56), Ben. Cav. ; Asst. to AGG. Rājputāna, 1842–52 ; 191.
Rock :—on hills, 203 :—inscribed for trgn. marks, 105, 176 469–70.
Rods, measg., wood or metal ; 209, 292, 300–3 ; v. Standard.
Rohilkhand, NWP., 81, 336, 376, 437 :—Rev. Svy., 6, 67, 258–62, 264–7, 294, 314, 318, 364–5, 396, 433, 435, 451, 456, 467, 494, 498, 500, 505, 536, 539 ; pls. 1, 16, 28.
Rohilla tribesmen, 177, 179, 485–6, 517.
Rohri, Sind, 8, 193, 277–8, 371 ; pls. 1, 5, 28.
Rohtak, nr. Delhi :—Canal, 50, 265, 269 :—Dist., 508 ; pls. 1, 5, 16, 28.
Rohtang Pass, Kulu, 186, 201–2, 516.
Roorkee, NWP. :—Thomason Engrg. Coll., 143, 164–5, 211, 217, 282, 284, 358, 408, 889, 424, 431, 436, 441, 443, 512, 543 :—*Prof. Papers*, xxvii, 286 :—*Treatise*, on building 110 ; pls. 1, 5, 28.
Rope 111, 203–4 206, 302, 484 : Bridge, 223–4 :—Meast. by, 292, 299–300.
Rose, FM. Sir Hugh Henry (1801–85), cr. Baron Strathnairn 1866 ; *DNB.*, *DIB.* ; GCB., GCSI., C-in-C. India, 1860–5 ; 485.
Ross, Alex. (1816–99), RGS., 1837 ; Supt. DDn. 1848–60, 268 :—Capt. Daniel (1780–1849), Mar. SG., 1821–33 [III, 499] ; *DIB.* ; 195–6.
Rossenrode, John Wm. (b. 1820), 13 n.1, 2, 17 n.1, 20 n.4, 60, 103, 193, 410, 413, 420 :—and his bro Wm. Chas (c. 1921–97) 8, 14 n.1, 19–20, 27–8, 31–3, 37–41, 43–6, 48–9, 83, 98–100, 109–10, 371, 403, 405–6, 408, 413, 416, 420, 456, 465, 468 :—Wm., their father (1792–1852), viii, 99, 413, 416, 458 ; all civ. assts. Trig.
Route :—*Books*, *Kashmir*, xxvi, 239, 515 :—*Map*, pl. 18.
Route Svys. :—Bengal, 23, 103, 291 :—Burma, 5, 195, 197–8, 498 :—Central India, 188–9, 309–10, 315 :—Chota Nāgpur, 184, 538 :—East Coast, 167–9, 175, 288, 385 :—NE. Frontier, 311 :—Nepāl Frontier, 252 :—Oudh, 314 :—Punjab, 201, 316, 337, 343, 423, 524 :—Rājputāna, 190–1, 316 :—Sind, 192.
Rowe, Josah, civ. survr., Calcutta [IV, 457], 182, 517 n.10.
Roy, Gen. Wm. (1726–90), RE. ; [II, 474], Conolly (7/127) ; os. of Britain, 1865–90 ; FRS., FSA. *DNB.* ; *Ency Brit.* ; 339.
Royal :—Engrs. (RE.), *Aide Memoire*, 78 :—Navy, 140 n.7, 512 :—Mil. Academy (RMA), "The Shop" Comdt., 495–6 :—Salute, 515 :—Warrant, 339 ; v. Sandhurst.
Royal :—Astr. Soc., 124, 131, 135, 490, 501, 503, 530, 532–3, 535, 544 :—Geogl. Soc. (RGS), 69, 89–90, 238, 324, 501, 506, 512, 516, 527, 540 :—Gold Medal, 339, 488, 494, 512–3, 531, 536, 541–2, 544 :—Gold Watch ; 508 :—Philatelic Soc., 335 :—Royal Soc., 186, 144–5, 501–3, 513, 527, 532, 540 n.6, 533 n.4 :—Fellows (FRS), 501, 503, 512, 532–3, 536, 538.
Rugby School, 488, 490, 492, 504.
Rūpar, Punjab, 35, 201–2, 206, 271, 517 ; pl. 6.
Rupees :—Company's, 347, 355, 405, 453, 479–80 :—*sonat* & *sicca*, 408.
Rupshu, Ladākh, 186, 234–7, 286, 425, 481, 490, 506, 515, 517 ; pl. 8, Rukshu.
Russell, Géo. Edw. (1786–1863), MCS. [IV, 533], 503 :—Richd. Henry (1821–63), BCS., his son, 504 n.2.
Russia, 146, 540.
Russian :—Geographers, 540 :—Maps, Central Asia, 146, 516, 540.
Russo-Afghān Boundary, 1884–5, 511.
Rust, 131, 163.
Ryall, Edw. Chas. (b. c. 1838), civ. asst. Topo., 111, 213, 231–7, 372, 410 n.3, 424–5, 428, 432, 513 :—Fredk. Wm. (b. 1842), 29 n.2, 420 :—& Geo. J. (b. 1839), both civ. asst. Trig., 53 n.4, 420.

Sābarmati R., Cambay, 57, 72–4 :—trgn., 118.
Sabāthu, Simla Hills, 496, 519 ; pls. 5, 6.
Sabine, Gen. Sir Edw. (1788–1883), RA. [III, 531], RSE., FRS., 1818 ; FRGS., 1852 ; FRAS., *Ency Brit.* ; *DNB.* ; 540.
Safed Koh Range, NWP., 47, 85–6, 91, 216–7, 317, 417, 511 ; pl. 2.
Sagar I., Hooghly R., 249, 357 ; pls. 1, 4, 28.
Sage, M Gen. Wm. (1793–1864), Ben. Inf. [IV, 464], 142.
Sahāranpur, NWP., 137, 258, 483 :—Lat. of Belleville [III, 38 ; pl. 5] 134 :—Rev. Svy., 261 ; pls. 1, 3, 5, 16, 28.
sais, or groom, 468, 474–5.
Saiyad Ismail, son of Mohsin Husain [III, 485], asst. Inst.-Maker 165, 358, 360.
sāl, forest, trees, timber, *shorea robusta*, 6, 23, 71, 75, 178, 252, 284.
Salary, 77, 145, 215 n.2, 346, 353, 356, 375–6, 398–9, 403–4, 407, 415, 433, 506 :—Bombay, 425–6, 429, 433–4, 437, 446, 449–51, 483, 507, 510 :—Increase, 385, 522, 526, 542, 544 :—of ancient times, 399, 408 :—of Rev. Survrs., 365, 398–9, 450–5 ; v. Allces.
Sale, Thos. Henry (1814–1903), Ben. Engrs. [IV, 464] ; Conolly (88/177) ; Hodson, IV (5) ; 312.
Salem, Madras :—Rev. Svy., 280 :—Topo. Svy., 383, 503 ; pl. 28.
Salisbury, Lord ; Robt. Arthur Talbot Gascoyne-Cecil, 3rd Marq. (1830–1903) ; Debrett, 1945 (906–7) ; *Who Was Who*, addn. (xi) ; SSI., 1866–7, 1874–8 ; PM. 1885–92, 1895–1902 ; 533.
Salmond, forest svys., Tenasserim, 1846, 194 n.6.
Salt :—edible, 174, 373, 466 :—Soil, 25, 40, 58, 108 :—Water, 234.
Salt :—Dept., Bengal, 477 :—Lakes, Calcutta [III, 13], 70 :—Range, Punjab, Jhelum to Kalabāgh, 4, 7, 37, 41, 51, 119, 144 209–14 274–5, 318, 375 481 :—pls. 1, 5.
Sambalpur, Orissa, 4, 27–8, 118, 167, 169–73, 174–6, 377, 482, 484, 526 :—Dist., 427 :—GTS. ; Longl. ser., 27, 172–3 :—Merdl. ser., 173, 510 :—Road svy., 288 :—Topo. Svy., 171–3, 495, 526 ; pls. 1, 3, 4, 16, 28.
Sanatorium, 175, 470, 488, 535.
Sand, 39–40, 79, 110–2, 526 :—bank, *diāra*, or *chur*, 174, 257, 262, 468 :—hills, 2, 39–40, 46, 467 :—stone, 231–2, 362, 512 :—storms 192, 410.
Sanders, M Gen. Arthur (1812–95), Ben. Inf. [IV, 464] ; Hodson, IV (13) ; 325, 348 n.2.
Sanderson, Wm., civ. asst. Rev., 259–60, 264, 433, 443.
Sandes, Lt.-Col. Edw. Warren Caulfield (b. 1880), RE. 1899–31, DSO., MC., OBE. ; auth. of *The Military Engineer in India* ; xxvii, 470,
Sandhurst, RMC., 389, 488, 494, 496, 503, 505.
Sandy country, 39, 47, 102, 111, 279 ; v. *bahr* ; Desert.
Sanger, Thos. B., civ. asst. Bo. Trig. [IV, 386], 54–5, 59–61, 141, 418, 420, 460.
Santāl :—Parganas, s. of Bhāgalpur, 13, 456, 522, pl. 16 :—Tribesmen, 372, 491, 499 :—Campaign of 1855 ; 529.
Sappers & Miners :—Bengal, 423, 488, 498, 513, 524, 541 :—Bombay, 444, 494, 500 :—Sikkim, 478.
sarai, or Rest House, 226, 508, 512 ; v. Bungalows.
Sāran Dist., Bihār :—Map, 313 :—Rev. Svy., 5, 241, 252, 303, 364, 434, 450, 543 ; pl. 16.
Saugor, CP., 145, 189, 396–7, 492, 494 :—Rev. Svy., 6, 268, 364, 379, 486, 492, 543 :—Siege of Fort, 492, 543 ; pls. 1, 3, 5.
Saugor & Narbada Territories, 143, 267, 309, 315, 538 :—Rev. Svy., 294, 543 ; pl. 16.
Saxton :—Dr. Chas., sch. mr. of co. Salop, 525 n.7, 527 :—Christopher

(d. 1570-96), *surv. & cartr., DNB.*; 527:—Chas. Clifford (1842-78), Mad. Art., 527.
Scaffolding, 23–4, 74, 103–4, 106, 108, 111, 118; v. Bamboo.
Scales of Topo. Svy. & Mapping, 169–71, 177, 180–1, 186, 200–2, 210; 213, 216, 218, 226, 276, 279, 282–3, 285, 288–9, 310, 421 n.2, 423; v. Map reduction; Maps, scales.
Scales, brass insts., 165, 209:—drawing of, 291, 305–6, 435:—for graduating insts., 532:—on levels, 157:—plotting, 278:—standard 6″, 158.
Scales, or balances, 307–8.
Schalch, John Aug. (1793–1825), Ben. Inf. [III, 500–1], 70, 181, 250, 312.
Schoo:—Boys, 402–3, 412–3:—Masters, 441, 443, 527.
Schools:—Calcutta, 358, 404, 432, 436, 543:—of India, 405, 442–3; v. La Martinière; Mussoorie; Stokes.
Science, 57, 139–45, 381, 496.
Scientific:—Depts., India, 94, 502:—Journals, 528:—Knowledge, 534:—Missions, 145–6, 527–8:—Obsns., 534–5:—Papers, 339, 529:—Principles, 281:—Societies, 535; v. Insts.
Scientists, 137, 183, 269.
Scotland, 437, 439, 502–3, 509.
Scott:—Capt. Chas. (kd. Lucknow, 1858), Mad. Engrs. 1847–58; Conolly (101/193), 196 n.4, 197:—Edwin Luddington (d. after 1888), Bo. Inf., 401:—M. Gen Francis Henry (1817–84), Mad. Cav., DQMG. Madras, 1854, 319:—Gilbert James, civ. asst. Trig., 227, 229, 232–4, 420:—James Wm., Bo. Rev. Survr., 1856–83, 445:—H., civ. asst. Rev., 443:—Robert (1822–74), civ. asst. GTS., Stores [IV, 441], 341, 343, 359, 374:—R. L., civ. asst. Mad. Rev., 445:—Stanley, Bo. Inf., 401:—Sir Walter (1771–1832) novelist & poet, *DNB.*; 528:—Wm. (1784/6–1827), asst. Rev. Survr., Mad. [III, 501–2], 360:—Wm. Henry (1811/2–73), Ch. Dmn., GTS., 95, 236–9, 291, 318, 341–3, 353, 369, 370, 498.
Sea:—Air, 516:—Bathing, 130, 539:—Crossed by trgn., 102:—Death at, 396, 497, 528:—Journey, duty or transfer, 9, 338 371, 438, 483, 489, 541:—Loss at, 159:—Transport, 77, 151:—Voyage for Health, 25, 27, 382, 459, 463, 465, 504, 538, 543–4:—Water, 15, 41, 58, 74; v. Coast.
Sea-Level:—Connection to, xv, 3, 23, 25–7, 29, 45, 55, 57, 62, 66–7, 70–1, 75, 90, 118, 523; v. Heights:—Mean, 62, 69–70, 72–4, 80, 534:—Hooghly R., 66, 70–1, 75:—Karāchi, 74–6, 539.
Season, favourable to svy., 39, 63, 168; v.; Field; Recess, Unhealthy.
Secondary:—Trgn., 2–3, 12–62, *passim*; 98, 101, 118–20, 126, 156–7, 190, 200–97, *passim*; 388, 409, 446, 449, 457, 475:—obsns. Snow Peaks, 83, 85, 94 156:—Stations, 35–6, 90, 101, 169, 297, 525; v. Points.
Secrecy, 402, 528.
Secretary:—of State for India (SSI), 94, 238, 324, 502:—to Ben. Govt., 353.
seers, unit of weight, 373, 479.
Semaphore:—Signals, coastal, 15, 25:—v. Telegraph, Visual; Timeball.
Senefelder (or Schneffelder), Alois, pioneer lithr.; *Ency Brit.*, sv. Lithography, 329 n.4.
Seniority:—Deptl., 519, 524–5:—Mil., 525, 537.
Sentries, 162, 377, 475.
Sepoys, 33, 44, 117, 142, 146, 168, 341, 364, 367, 377–8, 469, 471, 483–6, 481, 484.
Serampore, Hooghly R., 247–8 256, 332, 353; pls. 1, 28:—Coll. 443.
Servants, private, 173, 362, 364, 367, 371, 438–9, 455, 460, 463, 475, 480, 491, 496, 501, 518, 528:—Pay, 411, 489.
Settlement:—Revenues 194, 197, 261, 263–4, 284, 300:—Officers (80), 6, 188, 212, 214, 268–72, 274, 290, 293, 301–2, 350–1:—duties assigned, 212, 214, 268–72, 274, 290, 293, 301–2, 350–1, 495, 509:—duties assumed by Survrs. 244, 250–1, 275, 488, 497; 533:—Staff, 6, 8, 263, 277–8, 350; v. Comnr.; Revenue.
Sextants, 13, 187, 298.
Shāhābād, Bihār:—Maps, 313:—Rev. Svy., 6, 241, 244, 254, 299, 302, 364, 519, 529; pl. 16.
Shāhjahānpur, Rohilkhand, 258–60, 264, 437; pls. 1, 3, 4, 5, 16, 28.
Shāhpur Dist., Punjab, 214, 273–5, 530; pls. 1, 5, 16, 28.
Shaw, Henry Geo. (b. 1862), Metl. Dept., 1883–9; civ. asst. GTS., from 1889, 68, 93.
Sheep, 201, 203, 207, 364.
Shekhāwatī, Rājputāna [IV, pl. 3]; 50, 190.
Shekhbuddin Hill, NWF.; 32 m. N. of D. I. Khan, 47, 216–7.
Shelverton, Chas. (b. 1830), 28, 30–1, 51 n.3, 174, 345, 420, 461:—& his bro., both civ. asst., Trig., Geo. Henry Walter (1831–71) 5, 43 n.2, 52–3, 88–9, 111, 202, 207–8, 211, 225, 227–30, 232–3, 405, 408, 417, 420, 423, 426–7, 485, 517.
Shepherd, Chas., London clock-maker, *Airy* (213, 223); 140.
Shikārpur, Sind, 46, 48, 78, 80; pls. 1, 3, 5, 28.
Shilla Peak, Spiti by 1963 trgn., 20,050 ft.; 506; v. Parang La.
Shillong, Assam, 32, 418; pls. 1, 28.
Shipki, Upper Sutlej, 200, 204.
Ship, 24, 59, 153, 183, 357, 411, 463:—wreck, 371, 527.
Sholāpur, Deccan, 275, 533; pls. 1, 28.
Shooting:—Sport & Sportsmen 88, 307, 479–80, 491 n.1, 504:—target, 523.
Shore, Richd. Nowell (1821–1902), RCS., 1840–65; 245.
Shortt, Dr. John (1822–89), Mad. Med. 1854–78, Crawford's *Roll*, M 1197; Burkill, IV (355); 171, 464–6.
Shrine, religious, 470–1, 527.
Shuckburgh, Col. Henry Adolphus (1800–60), Ben. Inf., 529 n.4.
shujrah, map of fields, 263, 271, 293, 300.
Shyok R., Karakoram, 88, 187 232–3, 235–7, 425, 506, 515 536:—Village, 491; pl. 6.
Sialkot, Punjab, 7, 37, 52, 224, 296, 475, 489, 508, 514, 534–5:—Rev. Svy., 52, 270, 273, 530; pls. 1, 3, 5, 16, 28.
Sibpur Engrg. Coll., Calcutta, 182–3, 257; v. Bot. Gdns.
Sick:—Leave, 25, 167, 177, 375, 379, 385, 396, 417, 428, 461–2, 492, 496:—Followers, 373:—List, 76; v. Medical.
Sidons, Henry (1812–60), Ben. Engrs. [IV, 464], Conolly (88/173); 70.
Sight:—Line of, 63, 99, 114; v. Eye-Sight; Rays:—Rule, of plane-table, 215, 288, 302.
Signal:—Apparatus, 517:—Pole & Brush or Staff, 27, 35, 72, 112, 117, 203–7, 210, 212, 227–8, 287, 446, 471, 486, 493.
Signallers, 37, 40, 45, 47, 83, 110, 114, 117, 176, 216, 221–2, 225, 229, 233, 367, 377, 452–6, 459–60, 466, 473–4, 527; v. Heliotropers.
Signals, 38, 101, 114, 117–8:—Luminous, 41, 60, 65, 216, 222, 231, 261, 365, 198, 212, 287:—Interference, 212; v. Marks:—permanent, 221:—Topo. Svy., 173, 285–88; v. Centering; Lamps; Time.
Signatures, 121–2, 166, 247, 300.
Sikh:—Army, 2, 316, 423:—Country, xi, 474, 489:—*Mazhbis*, 500:—People, 162:—Rule, 220, 231, 524:—States, 7, 268–9, 316, 480:—WARS:—xiv, 1–2, 4, 316, 542:—1845–6, 7, 34, 86, 208, 220, n.4 269–70 n.4, 337, 364, 396, 433, 488, 492, 495, 500, 504–5, 531, 536, 544:—1848–9, 7, 35, 209, 214, 272, 423, 474, 488, 494, 496, 499–500, 524; 539, 544; v. Treaties.
Sikkim, 85–6, 90, 92, 95, 145–7, 161, 183, 186, 244, 448, 478, 528–9, 536:—Mahārāja, 83, 186:—People, 473:—SG.'s Svy., 83, 185–6, 337, 541:—Trgn., 19–20, 65, 69, 83, 361, 406; pls. 4, 16; v.; Darjeeling Peaks.
Silver:—Bullion, 522:—Ore, 142:—plating, 298.
Simla, 38, 86, 144–7, 200–3, 207, 237, 422, 496–7, 528, 532, 535:—Cart-rd. cem., 404:—Hills, 206, 429, 505:—States, 100 n.4, 471, 478; v. Bashahr; Bilaspur; Sirmur.
Simpson, Wm. (1823–99), artist, *DNB.*, 515 n.4.
Simms, Wm. (1793–1860), inst.-maker [III, 532], *DNB.*, *RAS* (*mn*), 67 (237); 153–4, 157, 159, 163, 298–9, 374, 531, 533; v. Troughton & Simms.
Sind, 1, 8, 27, 31, 40–1, 43, 46, 48, 59, 192–4, 276–9, 308, 379, 390, 406, 512, 535, 539–40:—Bdy. 45, 217:—British Occn. 192, 405, Frontier, 324:—Coast, 43, 307:—Lower, 109, 479, 495:—Riwys., 78, 403–4:—Rev. Svy., 1, 7–8, 192–4, 274, 276–9, 349, 351, 365, 391, 396–7, 434–7, 444, 452, 492, 494–5, 500, 510, 530–1, 533:—Svy., Forest & Canal, 192–3, 281, 437, 492, 495, 512, 528, 543:—Tower Stns., 105:—Trgn., 44–7, 97, 120, 416, 424, 492, 532:—Unpopular service, 437, 452, 462, 539, 542:—Upper, 48, 193, 277–9; pls. 1, 5, 28; v. Canals; Desert; Maps.
Sind R., Kashmir, 187, 224, 227–8, 505; pl. 6.
Sind-Sāgar *doāb*, Punjab, 7, 47, 213–4, 274–5, 284, 298, 318, 436, 509, 530, 535; pl. 16.
Sindhia:—Mahārāja of Gwalior, 188, 267:—Contt., 376:—Territory, 265 n.8, 316; pls. 1, 28.
Singalila Range, Nepāl-Sikkim, 186, 529.
Singapore, Malaya, 144; 244, 307, 535–6.
Singhi merdl. ser., Bo. GTS.; v. Konkan.
Sirmoor Batt.; v. 2nd Goorkha Rifles.
Sirmur State, 2, 34, 86, 157, 478 n.5; pl. 6, Nahan; v. Simla Hills.
Sironj, CI., xiv, 2, 37–8, 42, 56, 66, 75, 124, 129, 130, 188, 361, 376, 382, 469, 510, 523, 532; pls. 1, 3, 5, 16, 28; v. Base-lines.
Siwālik Range, Dehra Dūn [IV, pl. 17 n.1], 35, 105, 207, 393, 423, 496.
Skardo, Bāltistān, 88–9, 187, 220, 226–7, 232, 235, 240, 316, 425, 489, 493, 506, 515, 528, 536; pls. 1, 5, 6, 28.
Sketches:—Artistic, 284, 488, 499, 503, 528, Views:—Profile of Peaks, 84–9, 91, 95, 529; v. Panoramas:—Rough Maps, 5, 33, 184, 186, 195, 213, 220, 225, 253, 272, 489, 511; v. Hill-sketching.
Sketching, topo., 89, 197–8, 208, 210, 215–7, 219, 228–9, 235–7, 283, 288, 423–4, 502, 506, 517.
Smallpox, 461.
Smart, Arthur David (b. 1830), 433, 436, 443, & his bro., Robt. Broughton (b. 1827), 186, 243, 243, 246, 364, 433, 436, 443, 529, 535:—Robt. Boddington, appd. 1864, 443; all civ. asst. Rev.
Smith:—Anthony (1819/20–50), 244 n.6, 438, 439, 443 & Henry Maitland (1813/4–59), also civ. asst. Rev. [IV, 491], 443:—Henry Mariano (b. c. 1806), litho-dmn. & printer, 183, 327–8, 332, 335, 343, 348, 357 360:—James Benjamin (b 1837), civ. asst. Topo., 422, 432:—James Hawes, civ. asst. Trig., 28 n.3, 44, 46, 178–9, 404, 483:—John Jacob, mariner, 357:—Gen. Richd. Baird (1818–61), Ben. Engrs., CB., CE., Delhi, 1857, *DNB.*; *DIB.*; Conolly (89/194), d. at sea, 539:—Robt. (1787–1873), Ben. Engrs. [II, 442], Conolly (14, 315), VI:—Robt. Abraham (b. 1825), civ. asst. Rev., 433, 443.
Smoke:—Haze, 12, 24, 54–5, 117–8, 468:—Tobacco, 504, 535.
Smyth, Col. Edm. (1823–1911), Ben. Inf., Edn. Dept., Kumaun; Mason (84, 119), FRGS., 1869, 448; n.9.
Snell:—Maj. Chas. (1791–1841), Mad. Inf. [III, 504], 26, 167, 346, 432, 462:—Chas., junr. (d. 1857), civ. asst. Topo., 167 n.2, 168–9, 171–3, 421–2, 428, 432.
Snow:—Blindness, 206–7, 223, 513–4:—Depth of, 87–8, 94, 206–7, 222, 231, 489, 505:—Fall, 5, 21, 37, 63, 87, 206–7, 222, 224, 230, 234:—Hills, winter-covered, 21, 35, 98, 202, 203, 206–7, 221–5, 227, 231, 233–4, 237, 271–2, 423, 507–8:—Line, perpetual, 188, 203, 238, 430, 532:—Melted for water, 223:—Plume, 83:—Storm, 37, 223, 489; v. Himālaya Range; Peaks.
Sobraon, battle 10–2–46, c. 20 m. NE. of Ferozepore, lx, 492, 505, 524, 531.
Socks, woollen, 466, 495.
Sohāgpur, CP., 8, 143, 179, 266, 296; pls. 1, 4, 16, 28.
Soils, 40, 272:—Classification, 279.
Soldiers, 205, 378; v. British; Sepoys; Troops.
Son R., 13, 118, 255, 312, 410, 459, 462, 519; pls. 1, 3, 4, 28.
Soup, 183, 364.
South-West Frontier Agency, 170, 172, 308, 311; pls. 1, 16, 28.
Sparks, sketches in Burma, 196.
Speed of Rev. Svys.:—Bengal, 247, 255, 266, 269–70, 304:—NWP., 258, 294, 396:—Punjab, 269–70, 397:—Rājputāna, 266.
Speke, Capt. John Hanning (1827–64), explorer; Ens. Ben Inf., 1844; MI., Kensington Gdns.; *DNB.*, 494.
Spencer, transport agent, Multān, 77.
Spherical:—Excess, 35, 82, 118, 122, 282, 286, 525:—Triangles, 82, 513:—Trigonometry, 513.
Spiti:—R., Himālaya, 186, 202–3, 205, 234, 272, 316, 416, 496, 506, 509, 512, 528:—or Kulzum, Pass, 517; pl. 6.
Spleen, 58, 439.
Springs, hot, or sulphur, 148, 489, 512–3.

Srinagar, Kashmir, 69, 146–7, 187, 224–5, 227–34, 237, 289, 388 481, 485, 488–9, 491, 498, 505–6, 511–5, 518, 528, 536:—Town Svy & Map, 232–3, 239, 518; pls. 1, 5, 6, 14, 28; v. Kashmir.
Srinath Sickdhar, compr., 341, 354–6, 360.
St. George:—Fort, v. Madras:—Wm. (b. 1826/7), from pte. 14th Lt. Drgns. to civ. asst. Rev.; 437, 443.
Staff:—Corps: Bengal, 389, 488–90, 499, 505, 511, 519:—Bombay, 500:—Madras, 495, 503, 527:—Employ, 397; v. Signal.
Standard:—Bar or Rod, 20, 43, 75, 79, 158–60, 165, 259, 299, 523, 540:—Chain, 208:—Yard, 150–60:—of measure, 20, 125, 129.
Stapleton:—Chas. Thos. (1819–61), 359 & Edw., both writers, 358, 360:—Geo. H., Litho. Printer [IV, 350], 357.
Stars:—Circumpolar, 15, 122, 130–1, 133, 298, 525:—Catalogue, ix, 124:—Obsns. 197; v. Astr.
States, Indian, 188–92, 240, 266–7, 269–70, 294, 307–8, 346, 470, 475–6, 478–82, 527:—Svy., 190–1; v. Boundaries; Maps.
Statesman, The, daily newspaper, Calcutta & New Delhi, 335.
Stationery:—371:—Dept., 329–30, 332.
Stations, trig.:—Astr., 121:—Camping at, 222, 229:—Constn. 212:—Co-ordinates, 120:—Himālayan, 5, 36–7, 83, 157, 202–4, 208, 233:—Loss, 190, 260, 296:—Named, 233:—Peaks, 202, 221, 228, 235, 237, 505–6:—Pendulum, 121:—Preservation, 469, 113:—Rev. Svy., 260, 262:—Topo. 213, 216:—Selection 11–7, 26, 37–9, 47–8, 50–1, 57, 60–1, 83, 98–100, 102–4, 109, 111, 114, 158, 161, 169, 173, 184, 409, 415–6, 446, 471–2, 525, 540:—Traverse Svy., 253, 288:—v. Hill; Marks; Prepl.; 2dry; Tidal; Tower.
Statistical Regrs., Rev. Svy., 271, 293, 305.
Statistics, 180, 188, 192, 269, 271.
Steamers:—Assam, 311:—Bengal Rivers, 185, 305, 338, 437, 499–500:—Coastal, 59, 145, 194, 504:—Indus R., 43, 77, 131, 372:—P & O., 543:—other Sea-going, 140, 854, 527.
Stein, Sir Aurel (M. A.) (1862–1943), b. Buda-Pesth; traveller & auth.; KCIE., 1912; *Br. Ac. Progs.*, XXVII, XXIX, 240, 507.
Stephen:—Henry Virtue (1811–58), Ben. Inf. [IV, 468]; Hodson, IV (177); 7, 255, 266, 269–70, 364, 398, 400, 433, 435, 509:—J. J., civ. asst. Trig., 420:—Rum, 411; v. Bombay.
Stevens:—Henry, civ. asst. Rev., 256, 443:—Maj. James (1801–68), Ben. Inf., Hodson, IV (180); invd., Mussoorie, 1850; 341 n.3:—Wm., civ. asst. Rev., 437, 443.
Stewart, Dr. Balfour (1828–87), Dir. Kew Obsy. 1859–71, *DNB.*; 540.
Stimulants, 183, 460, 462:—Rum, 411; v. Brandy.
Stokes:—Prof. Sir Geo. Gabriel (1819–1903); Bart., FRS., 1851; *RS. Progs.*, LXV, 1905 (199–216); *Who Was Who*; 137, 540:—School, Masri. [IV, 440 n.2]. *Ind. Arch.*, II/2, 1955 (101–12); 419, 436, 441–2, 501, 505, 520.
Stones, 45, 105, 112–3:—Building, 112–3:—Engraving on, 328:—on Mountains, 203, 228; v. *Lithographic*; Mark-stones.
Store:—Dept., 502:—Keeper, 343, 358–9.
Storms, 24–5, 27, 33, 37, 42, 68, 153–4, 178, 463, 468, 489, 491.
Stormy weather, 234, 613, 520.
Strachey, Sir John (1823–1907), BCS., Debrett. I 1945 (970); GCSI, 1878; LG. NWP., 1874–6; *DIB.*; x, 318 n.4, 531.
Straker, Samuel, litho. press-maker, Bishopsgate, London, 329.
Straw:—Bedding, 459–60, 466:—chopped, 112.
Stream, or *nadi*, 24, 260, 290:—Svy. of, 197, 252–3, 258–61, 278.
Stroke, paralytic, 434, 544.
Struve:—Freidrich Geo. Wm. (1793–1864), German Astr.; *RS. Progs.* XIV, 1865 (XX), 125 n.1:—Otto Wm., von, his son (1819–1905); *Ency Brit.*, Astle. RS., 1873, RAS., 1850; succ. father at Pulkowa Obsy.; *RAS.* (*mn*), LXVI (179); 540.
Stubendorff, Col. (Oberst) Otto Edw. von. (1837–1918); Russian Mil. staff; Geogr.; 540.
Sturt, J. L. D. (1811–42); Ben. Engrs. [IV, 468–9] ix, xi.
Sub-Assistants:—GTS., t-page; 5, 11–5, 17, 19–22 ns., 25–6 ns., 30–1 ns., 35–6 ns., 43, 46–7 ns., 131, 157, 163, 368–9, 381, 392, 402–20, 422, 429, 501:—Indian, 451:—Principal, 402, 405:—Rev. Svys., 244 n.6, 276, 365, 433–44, 499–500, 505, 510, 543:—Topo., Svy., 167–9 ns., 171–2, 176 ns., 178–9 ns., 196, 207, 227, 364–5, 377, 384–5, 421–45, 455, 479; v. Asstt.
Subordinate Merdl. series, GTS.: Bengal, xiv, 1–2, 11–6, 21, 67, 81, 97, 101, 113, 128, 130–1, 149, 155, 273, 292, 521; pls. 3–4:—East Frontier, 32:—Punjab, 34, 38, 49–53; pls. 3, 4:—Bombay, 38.
Subtense meast., 14, 72, 104, 120.
Suez, Egypt, 523, 526.
Sugar, 459:—cane, 118.
Suket State, 20 m. N. of Simla, 200, 202; pl. 6.
Sukkur, Sind, 46–8, 53, 58, 110, 131, 277–8, 316, 370, 372, 509–10, 512, 534, 538; pls. 1, 3, 28.
Sulaimān:—Range, NWF., 47, 133, 218–9:—Takht-i-, 11, 100 ft., 540; pls. 1, 3, 5, 28; v. Takht.
Sultānpur, Kulu, 188, 201, 516; 60 m. N. of Simla.
Summers:—Chas. Aug. (1808–60/2), civ. asst. Topo [IV, 386], 36 n.4, 169–72, 202, 206, 421–3, 432:—Hector Hamilton, asst., Supt., Bo. Rev., Markham (450); 445.
Sun, 57, 65, 69, 84, 203, 261:—Altitude obsns., 147, 197, 357:—Exposure to, 374, 438, 460, 510, 536:—Heat, 456, 458–60:—Hour-angle, 154:—Rise, 20, 64, 73, 78, 84–5, 162, 464, 468, 473:—shine, 173, 225:—stroke, 59, 162; v. Eclipse.
Sundarbans, Bengal, 255, 441, 499:—Bdy. 241, 248–9:—Grants of land, 248:—Rev. Svy., 248, 353, 359, 442; pls., 1, 4, 16, 28.
Sunday, 78–9, 130, 343, 361, 411, 502.
Superannuation at age 65; 428, 430, 436, 442–3, 511, 522, 537.
Superintendent:—Canals & Forests, Sind, 193:—Dehra Dūn, 263:—Simla States, 478–9:—MIO., 162, 164, 166, 334, 348, 357:—Litho. Press, 328:—Pegu Svy., 5, 195–8:—REV. SVYS., 6:—Civil, 242–5, 247–8, 250–4, 267, 301–6, 350–1:—& Settmt., Bombay, 275–6, 398–9, 498:—& DSG. Bengal, after 1864, 512, 538–9:—Madras, 8, 280, 503, 521:—& SG., 336, 340–1, 428, 509, 537, 539:—& DSG. Topo., 334, 367, 428, 516; v. Orissa; Prof.; Rev. Survrs.
Supervision, or lack, 255, 304, 424–5, 451.
Supply of provisions, or *rasd.*, 21, 31, 38–9, 46, 53, 111, 174, 222, 229, 231, 362, 373, 377, 454, 476–9, 481, 506:—Carriage, 477, 480:—Demands, 470–1:—Shortage, or difficulties, 51, 278, 375, 421, 467, 477, 480, 493, 517, 527.
Surat, Bombay, 55, 460–1; pls. 1, 3, 28.
Surgeons, 414, 500, 518:—Asst., 142, 175, 177, 457, 464; v. Medical.
Survey Notes (*SI Notes*) pub. monthly 1884–1940, XXVII, 496.
Survey of India, Dept. so designated, XV, 341.
Surveyor General:—*Absence from* Calcutta, 164, 336, 339, 499:—Admin., 1, 9–10, 307, 342:—Appt., & succn., XIII, 6, 164, 336, 340–1, 348, 380, 495–6, 536–7, 539–41:—Combined role with STS., XIII, 1, 10, 336, 340, 537, 539–42:—Control, 4–5, 9–10, 54, 84, 90, 100, 126, 145, 167, 177, 180, 187, 192–8, 198, 209–10, 215, 217, 320, 363, 380–1, 384–5, 387, 402, 409, 423, 426, 444, 450, 458, 524, 497–8, 539; v. Rev. Svys.:—Dept. 1, 68, 140, 164, 498:—Disciplinary Powers, 390–1, 394–5, 497, 542:—Fd. work, 11–2, 44, 83, 377:—Mil. Rank 338–9:—Office work, 341–3:—Retirement, 340–1, 515:—Tours & Inspections, 10–2, 29, 42, 155, 185–6, 266, 336–8, 342, 376, 390, 393, 488, 499, 528, 525, 541:—36, 202, 211, 215, 287, 316, 337, 343, 424, 509:—Fd Hdqrs. & Office, 12, 20, 22, 42, 78, 121–2, 127–8, 183, 161–2, 323, 336–8, 341–4, 349, 368, 370, 372–3, 377, 404, 458, 501, 520; v. Allahābād; Dehra Dūn:—In ch. Topo. Br. from 1861, 340, 428, 537; v. Asst.; Cont. Bills; Darjeeling; Instns. Masri.; Peaks; Peshawar; Sikkim.
S.G.'s Office (660), Calcutta, XV, 139, 336, 338, 341–6, 351–60, 483, 499, 541, 536:—Premises, 69–70, 140–1, 164–5, 183, 328, 348–9, 351–2, 355–6, 499.
Surveyors, 139, 141–2; v. GTS. Staff; Nominal Rolls; Rev. Survrs., *Topo.* Staff.
Surveys; v. GTS.; Rev.; Topo. Village:—Closed down, 178, 192, 363, 384, 433–4, 450, 492–3.
Sutherland, M. Gen., James (1780/2–1850), Bo. Inf., KLS. 1810 [III, 504–5]; v. 191.
Sutlej R., Punjab, 5, 7, 34–6, 44, 53, 79, 200–4, 206–8, 269, 271 315–6:—Upper, 167, 201–8, 416, 422, 478–9, 505, 509, 517, 528, 536, 542:—Source, 187, 517; pls. 1, 3, 4, 5, 6, 16, 28.
Sutlej:—Army of, 1846, 524:—Boat traffic, 372, 484:—GTS., series, 3, 52–3, 49–50, 79, 503; pls. 3, 5; v. Cis.-& Trans.-Sutlej Rev. Svys.
Swamps, marshes, *jhils*, 2, 6, 12, 25, 62–3, 102–3, 108, 143, 231, 245, 255–6, 259–62, 272, 278, 290, 340, 371, 373–4, 463, 466–8, 538.
Swat valley & tribesmen, NWF. [IV, pl. 16], 37, 215 n.7, 236, 474–5, 481, 538.
Sweepers, 347, 367, 411.
Swetenham R., civ. asst. Rev., 196, 443.
Swiney, Geo. S. (b. 1822/4), 433, 443, 484 & his bro. John (d. 1848) 242, 246, 304, 433, 450, both civ. asst. Rev.
Swords, 449, 473–4, 500.
Sylhet, Bengal, 2, 29, 31–3, 184, 373, 484, 510:—Lt. Inf., 484:—Rev. Svy., 6, 184, 243, 254, 364, 536; pls. 1, 16, 28.
Symbols, map, 32, 317.
Symmetry of triangles, 3, 11, 18, 20, 84, 99–102, 114, 130, 174, 203, 211, 221, 233, 286, 409; v. Lay-out.
Synoptical volumes GTS. XXVI, 129, 239, 428.
System:—lack of, 26, 267, 530:—Topo. Svy., 168; v. Trigl.; Uniform.

Tables:—Compn., 122–4:—Traverse, IV, 265, 297, 529, 531; v. Astr., Auxiliary; Logarithm; Projection.
Tahsil, admin. div., 212.
tahsildhar, 263, 301, 377, 413, 471.
Takht-i-Sulaimān:—NWF., v. Sulaimān:—Kashmīr, or Shankara-Shariya, 6,263, ft.; 230, 516; pls. 13, 14, 15.
Talbot, Henry Blaquière (b. 1830), civ. asst., Topo., 1848, Rev. 1852, 36 n.4, 202, 210–1, 267 n.6, 422–4, 432, 436, 443, 471.
tāluk, admin. partition, 9, 200, 280, 285; v. *pargana*.
Tanks, or reservoirs, 12, 39, 191, 245, 248 n.9, 250, 456.
Tanner, Henry (1781–1854), Ben. Inf. [III, 505], 255:—Miss Tanner, dau. of Col. Henry Chas. Baskerville Tanner (1835–1898), Ben. Inf. & SC.; Svy. Dept., 1862–90; 538.
Tantia Topi (c. 1819–59), rebel leader 1857–9; *Ency Brit.*; *DIB.*, 179, 485.
Tapling, Thos. Keay (1855–91), philatelist, bar.; MP. 1886–91; Boase; 335.
Tapti R., Mālwa, 55, 178, 192, 324; pls. 1, 3, 16, 28.
tarai, forest belt below foot-hills, 10, 16–7, 26, 31, 63, 84, 97, 99, 104, 119, 258–62, 316, 324, 336, 456–7, 459–60, 462, 467, 501, 541.
Tartars, nomadic tribes of Central Asia, v. Balfour, V (31–2); 203, 206, 208, 234, 236, 506.
Tartary, Central Asia [I: pl. 11], 201, 204, 236, 426, 506, 517.
Tassin's:—Maps of Assam, VII, IX, 312:—Printing Press [IV, 469], 315–6, 325.
Tatta, Sind, 39, 44, 59, 78, 80, 372; pls. 1, 5, 28.
Taungu Pass, Arakan, *c.* 50 m. N. of Ramree, 95, 495; pl. 1, 28.
Taxes, 182, 185, 292.
Taylor, Gen. Sir Alex. (1926–1912), Ben. Engrs.; Conolly (90/224); GCB., 1889; *DIB.*; *Who Was Who*; 493:—Capt. Alf. Dundas (1825–98), IN., 2–6–41; Supt., Mar. Svy. 27–7–74; FRGS., 73:—Capt. John Wm. (d. at sea, 1874); Ben. Art., Lt. 1858, 400:—Col. Philip Meadows (1808–76), Nizām's service, OBI.; *DNB.*; *DIB.*; Cadell; 268.
Tea, ix, 183, 203, 311, 411, 459:—Plantations, XXV, 242, 505.
Teak, *tectona grandis*, 151, 160, 194 n.6, 196 n.6.
Telegrams, 32, 489.
Telegraph:—Burma, 141, 379, 395, 497, 531:—Bengal, 140–1, 388, 525:—Electric, 1, 15, 140–1:—Indo-European, 516, 525:—Lines Burma, 196, 431 n.1:—Visual, [III, 269–82], 24, 108, 140, 249:—Workshop, Calcutta, 141, 360.
Telephone, 141.
Telescopes, 85, 104, 120, 158, 208, 224, 256, 357, 374, 481, 507, 533, 535:—of Theodolites & Levels, 34, 151, 153, 159.
Temperature:—by thermometer, 14, 69, 529:—of atmosphere, 64–5, 159:—of insts., 20, 159:—of spring water, 512.
Temples:—survd., 18, 26, 119, 174, 222–3, 296, 472:—Hindu & Buddhist, 35–6, 51–3, 61, 187, 472–3.
Tenasserim, Burma, ix, 194, 244, 308, 490, 498, 538.
Tents:—for base-line meast., 158:—or bivouacs, 459–60:—pegs,

260 :—Transport for, 278, 362 :—SVY. CAMP, 25–6, 28, 73, 79, 170, 206–7, 212, 361, 363–4, 367, 459–60, 464, 466, 473–4, 500, 510, 520 :—Obsy., 41–2, 150, 153, 224, 361–2, 373, 467, 514 :—Office, 251, 361, 369, 373 :—Officers, 173, 371, 458, 518, 536, 544.
Terra incognita, unknown country, 227, 237, 315.
Terry, Geo. (b. 1818), civ. asst. Trig., 13, 17–8, 402, 410, 412–3, 420.
Text-books, xvi, 215, 345.
Thacker & Co., booksellers, Calcutta [III, 214 n.4], 124, 283.
Thackwell, Gen. Sir Joseph (1781–1859), IG. Cav., India, 1854; KH., GCB., 1849; *DNB.*; *DIB.*; 523.
thak, boundary mark, 247, 299 n.8, 301.
thakbast, lay-out of bdy. marks, 8, 242, 247, 251, 259, 270–1, 299–301 :—rough sketch, 212, 247–8, 271, 278, 294, 302; *v. misl* :—Comparison with prof. svy., 247, 451; *v. khasrah*.
Thākur Das, leveller, 77-9.
thāna police div., 243, 257 :—bdy., 212, 243, 257.
Thāna, Bombay, 375, 398, 498, 511, 533; pls. 1, 18, Tannah, 28.
Thatch Roof, 364, 474.
Theft, or thieves, 47, 56, 378, 482; *v.* Robbers; Robbery.
Theobald, Wm. (1829–1908), Geol. Svy. 1849–81; 142, 144.
Theodolite :—GTS., 86, 98, 104, 106, 148–58, 162–6, 221, 392, 394 :—GREAT, or 3-ft., 34, 54, 162 :—Cary-Barrow, 36-inch, 13, 16, 18, 38–40, 42–3, 47–8, 84, 115–6, 120, 148, 150–1; 513 :—T & S., 34-in., 17, 38, 47, 49, 53, 122, 138, 148–52, 392, 532 :—Stranges, 3-ft., 10, 151–2, 533 :—24-INCH, 10, 22, 54, 115 :—Barrow's, 17, 148–9, 153, 155, 523 :—T & S., 24, 28, 47, 49, 109, 138, 148–9, 153–5, 386, 513, 525, 532 :—Waugh & Mohsin Husain, 16, 21, 30, 34, 98, 148–50, 152–3, 221–2, 358, 394 n.6, 504, 514 :—18-INCH :—Mohsin Husain, 18 n.4, 148, 156 :—T & S., 10, 22–4, 54, 56, 99, 131, 148–9, 155–6, 392 :—15-INCH :—Cary's, 17, 19 n.1, 148 :—Dollond, 54–6, 148, 152, 156, 162, 392 :—Harris-Barrow, 17, 82, 148, 156 :—14-INCH, 37 n.10, 157, 221–2, 286–7, 514 :—12-INCH, 35, 60, 83, 85, 119, 148, 157, 162, 164–6, 209, 287, 298, 385, 474, 518 :—8-INCH, and smaller; Everest's, 98, 157, 165 :—others, 119, 148, 156–8, 169, 205, 208, 214–7, 246, 277, 287–8, 343, 410, 446, 448, 385, 495, 500, 507, 525 :—Robinson's 5-inch [IV, 139–40], 298–9 :—modern glass arc, 168; *v.* Vernier.
Theodolites :—Alterations & Adjustments, 38, 156, 392–3 :—Cleaning, 156, 163, 298 :—Collimation, 149–51, 162–3 :—Damage, 56, 150, 155, 392, 374, 523 :—Looted, 162, 271 :—Packing, 150–1, 158 :—Reconstruction, 148, 150, 152, 155, 166, 299 :—Repairs, 151, 155–6, 164–6, 296 :—Levelling, 114 :—Stands, 151, 154, 156, 165–6, 215, 287–8, 392–3 :—Testing, 137–8 :—Transport, 24, 34, 38–9, 149–52, 157, 222, 371 :—Weight, 150–2, 495, 513 :—Worn-out, 148–9; *v.* Indents; Graduation; Traverse.
Thermometer, 45, 158 :—for height by boiling-point, 69, 187, 228, 235, 238; *v.* Height :—OBSNS., 140, 203, 212, 233, 529 :—Corresponding, 139, 344; *v.* Temperature.
Thomason, James (1804–53), BCS. [IV, 471], LG. NWP., 1843–53; *DNB.*; *DIB.*; 262–3, 282, 284, 293 n.2, 313, 396.
Thompson :—Claude Matthew (1883–1952), ISC., S of I., 1907–48; 508 n.3 :—Corrie & Geo. V. (b. 1830/1), both civ. asst. Rev., 433, 443 :—Sir Wm. (1824–1907), cr. Lord Kelvin 1892; *DNB.*; *Who Was Who*; 540.
Thornton :—John, civ. asst. Rev. [IV, 385, 400], 183–4, 242 :—H. L., civ. asst. Rev., 443.
Thuillier, Leslie Cardew (1877–1964), ISC., S of I. 1897–1932, 536, 538.
Tibet, 83, 187, 319, 393, 515, 528, 531–2; pls. 1, 28 :—Little, *v.* Bāltistān :—Frontier, 145.
Tibetan :—Antelope, 235 :—Furse, 234, 236, 528 (Juniper ?) :—Language, 233 n.1, 448 :—Names, 95–6 :—People, 89, 425.
Tidal :—Bore, 57, 73–4; *v.* Creeks :—Obsns., xv, 27, 29, 42, 46, 69–75, 91, 504, 534, 540 :—Rivers, 80, 468 :—Stations, 3, 25, 28, 57, 59, 67, 74, 77.
Tide :—GAUGES, 70 :—East-Coast, 25, 27, 29, 71–2 :—West-Coast, 57, 67, 74, 159, 518 :—Karāchi, 44, 72, 74–5 :—Kidderpore, 21, 66, 69–71, 183 :—REGRS., 70.
Tides, 69–75, 104, 174, 540 :—High, 174, 540 :—Spring, 70, 73; *v.* Low.
Tieffenthaler, Father Joseph (1710–85) [I : 388], 240.
Tigers, 207, 431, 460, 467–8, 499, 504, 529 :—Bengal, 391.
Timber, 23–4, 105 :—Business Firm, Kashmir, 505.
Time :—Astr. Obsns., 126, 130, 147, 356–7, 448, 522; *v.* Astro.; Sun :—BALL :—Signals :—Ft. Wm., 138, 140–1, 351, 356–7, 522, 537, 543 :—Strand, London, over El. Tel. Off., now Barclay's Bank; view, *ILN.*, 27-12-1862; 19-12-1962, 140.
tindal, head *khalāsi*, 41–2, 84, 266, 296, 363, 365, 452–3, 455, 462.
Tinnivelly, S. India, viii, 279–80; pl. 28.
Tippera Dist., E. Bengal, 6, 243, 246, 256, 362; pls. 1, 3, 16, 28.
Tipu Sulatan, of Mysore (1763–99), [I : 110–8]; *DIB.*; xiii.
Tirhut, or Muzaffarpur, Bihār; Rev. Svy., 5, 241, 245, 252, 302, 306, 434–5, 437, 510, 518, 543; pls. 1, 16, 28.
Tista R., Bengal, 186, 369, 448, 489; pls. 1, 4, 28.
Titalia, Bengal, 14–5, 86, 338, 502; pls. 1, 28.
Title :—Courtesy, 345, 471 :—of Map, 291–2.
Todar Mal, Akbar's Minister [I : 133], 231–2.
Todhunter, Isaac (1820–84), mathn., FRS., 1862; *RS. Progs.*, 38, 1884 (xxvii), *DNB.*, 502, 540.
Todd :—James, civ. asst. Rev., 443 :—Wm. (b. 1838), civ. asst. Topo., 213, 231, 234–7, 278 n.4, 425, 432.
Tolly's Nullah, Calcutta [I : 63 n.2], 181, 249.
Topographical :—Art. 336, 387 :—Details, 68, 118, 181, 184, 232–3, 281, 284–5, 446 :—Drawing, 353, 421, 435 :—Experience, or lack, 120, 363, 379, 422, 492, 497, 516 :—SVYS. xiii :—by Rev. Survrs., 7, 242, 250, 253, 258–9, 261, 264–70, 273–5, 277, 279–80, 282, 284, 295, 300 :—by Trgtrs., 15, 38, 51, 103, 119, 314 :—by Topo. Parties, 1, 8–5, 10, 118–9, 144, 167, 219, 282, 288–9, 423–4, 434–5, 476 :—Lack of, 10, 22, 305–6, 310, 312; *v.* Blanks :—High standard demanded, 177, 281, 541 :—Published Reports, 343.
Topo. Svys. :—Bengal, 181–5; Berār, 177–9, 363, 371, 416, 495–6, 517–8 :—Bombay, 7–8, 54, 57, 191–2, 449–50 :—Burma, 194–5, 497–8 :—Ganjam & Orissa, 4, 142–3, 167–76, 421–2, 495–6, 525–7 :—Himālaya, 2, 4–5, 36, 136, 200–8, 220, 311, 393, 422–3, 496, 516–7 :—Hdbd., 3–4, 34, 177–9, 383, 395, 422 :—Kashmir, 5, 225, 229–36, 385–90 :—Khāsi Hills, 32–3 :—Kumaun & Garhwāl, 428, 516 :—Madras, 8, 34, 168, 179–80, 280, 310, 379, 381, 421 :—North Deccan, 1875, 512 :—Punjab, 4–5, 37, 208–19, 274, 287, 289, 337, 387, 423–5 :—of Br. OS. 502 :—Sind, 277–9; *v.* Central India; Ch. Nāgpur Instns.; Maps; Trgn.
Topo. Staff :—Topo. Branch, from 1861, 10, 341, 389–90, 428, 436, 489, 506, 524, 537 :—Supt., 340–1, 390, 516, 537 :—Survrs., 383–90 393, 399–400, 403, 414, 423, 425, 496, 504, 524; *v.* Assts.; Nomina Rolls; Sub. Assts.; Training; Parties.
Toungoo, Burma, 197, 531.
Towers, GTS. :—Assam, 29–31 :—Bengal, 105–8 :—Bombay, 57, 60, 68, 117–8 :—Calcutta: Base-line, 21, 24, 66, 70–1, 106, 108, 469, 504 :—Merdl. Ser., 15 :—Coast Ser., 23–6, 105–6, 108–9, 415, 504, 525 :—Ganges Valley, 12–4 :—Gt. Indus ser., 45–6, 48–9, 109–11, 448, 467, 509, 540 :—Gt. Longl., 39, 41–2, 109 :—NE. Longl., 16–21, 84 :—Punjab, 3, 50–3, 107, 109–12 :—N. Sind, Jacob's, 279 :—Secondary trgn., 119.
Towers :—Building, 2–3, 17, 20, 41, 49, 82, 98–9, 105–6, 108, 409, 476, 525 :—Collapse, 25, 30–1, 41, 45, 51, 83, 100, 107–9 111 :—Connected by Levelling, 76–7, 504 :—Cost, 106, 110–2, 155 :—Deflection or Settmt., 19, 30, 41–2, 105–9, 111 :—Design, 23, 105, 107, 111–2 :—Foundations, 46, 50, 106, 102–12 :—Height, 18, 24, 26, 41, 46, 64, 99, 105–6, 109–11, 117–8 :—Martello, English S. Coast, 74 :—Perforated, 21 n.3, 106–7, 109–10, 112 :—Raising Inst., 20, 53 :—Re-building, 30–1, 49, 110–1 :—Siting, 26, 102–4, 109, 415 :—Stations, 63, 110–3, 250, 410, 463 :—Steps or stairs, 20, 105–6, 109, 150 :—Washed away, 49, 100, 107–8.
Towns, Cities & Cant.:—connected, 2, 26, 36, 41, 98, 118, 126, 184 :—Plans 245, 324, 331; Presdcy. xiii :—Svys., 185, 232, 239, 245, 252, 259, 261–2, 277, 319, 324; *v.* Calcutta.
Tracing Glass, 165.
Training & Instn.; t-page:—Astr. Obsns., 131, 448, 516 :—Compa., 344 :—GTS., xiv, 10, 22, 35, 138, 163, 339, 344, 380–3, 402–6, 409–10, 414, 416, 541 :—Topo., 4–5, 167, 178, 213, 225, 229–30, 236, 290, 384–8, 390, 394, 421, 424–6, 442, 505–6, 514, 525–6, 533 :—Rev. Svy., 263, 396 :—*khalāsis*, 452–3, 455; *v.* Instns.
Transport, 24, 31, 111, 213 :—Animals, 172, 203, 362, 370–2, 405, 532 :—*v.* Baggage; Bullocks; Carriage Elephants; Expenses; Insts; Theodolites.
Trans-Indus :—Country, 4, 265 :—Map of Frontier, 311, 317, 340, 376, 387, 397, 508 :—Svy., 4, 209, 211, 216, 218, 317, 524.
Trans-Himālaya, 187, 540.
Trans-Sutlej, Punjab, 200, 204 n.3, 269, 318, 471 :—Rev. Svy., 272–3, 294, 364–5, 396–7, 435, 491–2, 504, 510; pl. 16n.
Trant, Thos. Abercrombie (1801/2–32), HM. 95th Ft. [III, 597–8], viii, 195.
Travellers, 89, 230, 494.
Travelling :—Allces., 145, 346–7, 375–6, 387, 399, 405, 407–8, 429, 434 :—Expenses, 77, 347, 371, 376, 387, 399, 405–6, 408, 411, 429, 437, 489, 499 :—in Jungle, 468 :—by Public vehicle, 371–2, 393 :—on Transfer, 371, 407.
Traverse :—Bdy. 210, 264 :—Circuits, 218, 243–4, 252, 255, 272–3, 278, 281, 297–8, 494 :—Compass or Theodolite, 185, 215, 255, 277, 292–3, 297–8 :—Control, 270, 297–8, 303–4 :—Forests & Hills, 260, 297 :—Network, 5, 195–7, 497, 543 :—Svy., 215, 285, 288, 540 :—Theodolite & Chain, 195–7, 218, 249, 252, 265, 281–2, 292, 297, 423, 447 :—*v.* Circuits; comps. Instns.; Perambulator, Tables.
Traversers, 304, 425, 450.
Treasure, transport of, 376, 454, 473.
Treasury, Govt., 328, 368, 376–8, 484–5.
Treaties, French, Chandernagore, Jan. 1873, 178 :—Gulāb Singh, Amritsar, 16–3–46, 220 n.5 :—with Nizām, Berār, 1804, 1853; 178 :—Sikhs, Lahore, 9–3–46; 186, 269 n.3 :—Sikkim, 1–2–35, 186.
Trebeck, Geo. (d. 1825), traveller [III, 508], viii, 186–7, 220, 317.
Trees, 2, 40, 52, 543 :—Bdy. marks, 259 :—Bridges 203 :—Clearing 24, 58, 60, 98–9, 103–5, 261, 413, 477–8, 526 :—Lopping, 104, 198 :—Obstacles 103, 105, 173 :—Signals, 174, 176, 252, 260, 287–8; *v.* Forest; Fruit Jungle; Pine; *Pipal*; *Sal*; Teak.
Trgn.:—Naini Tāl, 259 :—*v.* Assam Longl.; Bihār; Bombay; E. Coast; Errors; Gt. Arc.; Gt. Indus; Gt. Longl.; Gt. Trigl.; Gujarāt; Kashmir; Kāthiāwār; NE. Quadl.; NW. Quadl; Peshāwar; Rājputāna; Sind.
Triangles :—Length of Sides, 90, 98, 101, 104, 111, 119–20 :—Long, 67, 104 :—Short, 3, 29, 40, 46, 49, 64 :—Network, xiii, 101, 167, 190, 200, 282, 286–7 :—Obsn. of 3 angles, 287; *v.* Chāin; Lay-out; Spherical; Symmetry :—CHAIN, or series :—Double or compound, 22, 45, 47, 49, 55, 59, 98, 101–2, 175 :—Single, 14–5, 45, 53, 60, 97, 101–2, 130; *v.* Approx.
Triangulation :—Impracticable, 195, 543 :—Unconnected, 281–2 :—by Rev. Survrs., 261, 264–5, 267, 271–2, 276–7, 280, 292 :—Topo. Svy., 4–5, 36, 119, 121, 167–79, 184, 188–92, 195, 198, 201–3, 206, 209–12, 216, 251–2, 295–7, 385, 416, 421, 426, 483, 517; *v.* Charts; Minor; Points; Principal; Secondary.
Triangulators :—GTS., 97, 230, 234, 270, 287, 295, 387, 408, 416, 422 :—Topo., 197, 205, 271, 387, 422, 472, 485–6.
Tribal Territory, 215–9, 475, 508, 529.
Tribesmen :—C. India, 38 :—E. Coast, 167–8, 526–7 :—Nīlgiris or *todas* 8, 179 :—NWF., 538 n.5 :—Pathāns, 4, 47, 49, 151, 215–9, 311, 474, 508 :—Sikkim, 83; *v.* Baluch, Bhils; Khōnds.
Trichinopoly, 38 :—Rev. Svy., 9, 280, 503 :—Top Svy., 504; pl. 28.
Trigon, South, GTS., 540.
Trigl. :—Branch, 10, 341 :—Data, 127, 145 :—SVY. :—Everest's system 3, 131, 141, 337, 345–6, 476 :—of Gt. Britain, 523 :—Lambtons', xiii, 365; *v.* GTS.; Control; *v. Instns.* Points.
Trigonometry, 388, 446, 501.
Trijunctions :—*pargana*, 186, 294–6 :—Village, 52, 68, 120, 210, 212, 251, 260, 262, 297, 302.
Trikota Hill, Jammu, 2, 35–7, 472, 480.
Tripura State, 184; *v.* Tippera Dist.
Troops :—Company's (HEIC), xiii, 32, 191, 320–1, 349, 366, 372, 374,

377, 484 :—Indian 173 :—Local, 173 :—Pay, 376 :—Patiāla State, 480 :—v. British ; Madras ; Madras HM's.
Trotter, Lt.-Col. Sir Henry (1841-1919), RE., 1860-90 ; *Addiscombe* (646) ; Sandes, H. (298) ; Conolly (94/857), KOMO., OB., GTS., 1863-75 ; *DIB.*, 516 :—Wm. E., civ. asst. Trig., 53, 420.
Troughton & Simms, Inst.-makers [IV, 493], 34, 56, 77, 146-56, 159, 162, 299, 523, 581 ; v. Simms.
Tucker, Thos. Tudor (1817-57), Ben. Inf., DAQMG. Punjab, 1850, 816.
Turkistān [IV, pl. 16], 237, 448 :—Turki people, 447 n.5, 528.
Turnbull, Wm. Henry (1810-58), civ. asst. Topo., 169-70, 178, 421, 428, 532.
Turner, Samuel (1757/8-1802), Ben. Inf. [I : 394], 83.
Tweedale, Wm. Hutton (1803-83), Ben. Cav., Inv. ; xi.
Twenty-four Parganas Dist., Bengal, xiii, 6 :—Rev. Svy., 241-2, 248-50, 283, 294, 299, 304, 306, 397, 435, 536 ; pl. 16.
Twisden, F. E., IN., HRIC.'s *Pluto*, Burma, 1852, *IO Cat.* (120), 196.
Typhus & Typhoid fever, 456.

Udaipur, Rājputāna, 38, 51, 56 n.1, 191 ; pls. 1, 8, 5, 28.
Ujjain, Mālwa, 55, 376 n.3 ; pls. 1, Ougein, 3, 28.
Umarkot, Sind, 41, 58, 371 ; pl. 5.
Underwood, John James (d. 1864), Mad. Engrs. 1816-45 ; Conolly (98/117) ; vi, viii.
Umbrella, 223, 284, 460, 536.
Uncovenanted service, 172-3, 278, 365, 402-4, 407, 426-8, 431, 489, 494, 501-3, 505, 509-11, 516, 518, 520, 537, 543-4.
Unhealthy :—Country, 2, 4, 30-1, 50, 99, 168, 254-5, 289, 362, 368, 370, 375, 394, 421 :—Season, 18, 84, 170, 173, 245, 262 ; v. Forest ; Jungle.
Uniform :—Mil., 378 :—System of Svy., xiii, xv, 22, 114-5, 122, 195, 278, 338-9, 392, 530 ; v. System.
Uninhabited country, 28, 42, 170-1, 174, 198, 243, 375.
Units of measure :—Linear, 160, 299, 302-3 :—Area, 301-3.
Up-Country :—Alice., 454, 522 :—Svys., 433, 436.
Upper :—India, 426, 433, 447, 453, 456 :—Provs., 184-5, 355, 452, 456, 482 :—v. NWF.

Vanderputt, John Alexander (1845-81), civ. asst. Topo., 422, 432.
Vanrenen, Brig. Jacob (1762-1828), Ben. Inf. [II, 402, IV, 221], 538.
Vaughan, James, civ. asst. Rev., 263, 443, 488.
Venus, transit of, 1874 ; 152, 380, 502, 533, 535.
Vermilion colour, 332, 334.
Vernier scale, 148, 157, 287, 343, 385, 410 ; v. Theodolites.
Vernieux :—Lawrence Prudence (b. 1814), dmn., 354, 360.
Vertical Angles, 24-5, 80, 56-7, 60, 62-7, 72, 76, 80-2, 85-6, 91-2, 95, 117, 152, 157, 159, 169, 217, 290, 385, 514 :—Reciprocal, 53, 60, 62-6, 75, 88, 90, 212, 235 :—Simultaneous, 62-5 :—to Snow Peaks, 83, 85, 88-9, 91, 93, 228 :—Comps., 121, 522 ; v. Circle.
Vibration, of inst. or tower, 106-8, 110, 153, 160 ; v. Isolation.
Victoria :—British Queen, 89 n.3 :—Cross, mil. decoration, 538 :—Memorial Hall, Calcutta, 151, 153, 529.
Views, or sights, 141-2, 224-5 ; v. Panoramas ; Sketches.
Vigne, Godfrey Thos. (1800-63), traveller & auth. [IV, 472], ix, 87, 187, 220, 228, 238, 240, 317.
Village :—Headman, 176, 185, 377, 470, 475-6 :—Maps & Plans, 7, 9, 243, 251, 258-9, 263-6, 269-72, 276, 280, 284, 292-3, 295, 305-6, 313, 352, 450 :—Measts., 303-4 :—Officials, 113 :—Names, 257, 480 :—Proprietor, 299 :—Records, 7-8 :—Sites fixed, 18, 103, 160, 184, 197, 201, 216, 218, 244, 246, 252-3, 258, 280, 296-7, 312, 448, 479 :—Svys., xiv, 7-8, 245-8, 255, 263, 267-70, 279, 285, 300-1 ; v. Area ; Bdy. ; Circuit ; Trijunctions.
Villagers, 43, 219, 253, 275, 279, 301, 303, 468, 477, 499 :—as suspicious or unfriendly, 470, 475, 489, 527 ; v. Assaults ; Disputes, Guides.
Villages, 40, 52, 119, 168, 174, 187, 191, 230-2, 254, 362, 377 :—Congested, 468 :—Deserted, 177, 260 :—Lists of, 214, 257, 478 :—Mapping 184, 214 :—Obstruct svy. 174, 504 :—Ruined, 48, 50 :—Scarcity, 117, 229, 468, 479, 517 :—Scattered, 38-40.
Violence, 46, 177, 191.
Visibility, 19, 24, 40, 42, 46, 82, 98-9, 101, 103, 117, 223, 365-6 :—Inter-, 51-2 :—Poor, 14, 212, 366, 410, 533 ; v. Peaks.
Vizagapatam, E. Coast, 28-9, 72, 177, 370, 414, 490 ; pls. 1, 3, 28 ; v. Base-lines.
Vlacq, Adrian (1600-67), mathn., pub. log. tables, Holland, 1628, *Ency. Brit.*, sv. Logarithms ; 123.
Voysey, Dr. Henry Westley (d. 1824), asst. surgeon & geolgt. [III, 509-10], viii, 19 n.2, 142.
Vyall, Wm. Robt. (1838/9), civ. asst. Rev., 436, 443.

Waddell, Lt.-Col. Lawrence Augustine (1854-1938), IMS., *DIB.* ; Crawford's *Roll* (B. 2139), *Who was Who*, III ; CB., CIE. ; 95.
Walker :—John (1787-1873), HRIC.'s Geogr. [III, 510-1], xiii, 9, 146, 182, 238-40, 307-9, 316, 318, 327, 330, 346, 520, 531, 540 :—J. & C., cartrs., 182, 319 :—Obsy., DDn., (JTW) 138 n.8.
Wallace :—Maj. Rayner (1826-71), Bo. Inf., 401 :—Lt.-Gen. Rowland Robt. (1830-1915), Bo. Inf., 80. Sind, 1856 ; *Who Was Who*, 278 :—civ. asst. Rev., 260 n.1, 443.
Waltair, nr. Vizagapatam, 466, 490 ; pls. 1, 28.
Walton, Wm. (1812/3-1901), mathn., Trin. Hall, Camb., "Old Father Time", ob. *The Times*, 11-9-1901 ; 502.
Ward, Ben. Swain (1786-1835), Mad. Inf. [III, 511-2], v, 8, 179, 346, 421 :—Comdr. C.V., IN., Burma, 1850, of HRIC. *Krishna*, Irrawaddy, 1851-9, Markham (28, 480) ; *IO. Cat.* (670), 196 :—W. Civ. asst. Rev., 267 n.6, 443.
Wardwan R., W. Himālaya, 88, 230 n.3, 513 ; pl. 6.
Warren, John (1769-1830), Capt. HM. 33rd Ft. [II, 449-53] ; Lt. Col. Jean-Baptiste François Joseph ; 24th Comte de Warren, 1816 ; xiv, 124.
Waste Lands, 6, 171, 211, 214, 218, 244, 264, 269 :—Svy., 272-3, 278, 282, 293, 416, 505, 519 :—Madras, 8 ; v. Darjeeling.
Watch, or timekeeper, 495 :—svy. by, 187, 195 :—Maker, 163 :—Watchmen, or guards, 56, 322 ; v. RGS.
Water :—for building construction, 283 :—Brackish, 2, 39, 58-60, 212, 256, 273, 449, 456, 518.
Water :—colour painting, 499 :—courses, svy., 250, 289 :—Fowl, 255 :—logged areas, 243, 245, 259, 303 :—Supply, 168, 479 :—Damage to Towers, 106-7, 112 :—Drinking, 39-40, 45-6, 51-2, 59-60, 78, 183, 223, 234, 256, 273, 278, 449, 457, 459-60, 479, Frozen, 11, 518 ; Scarcity, 53, 111 :—v. Wells.
Waterhouse, M Gen. James (1842-1922), Ben. Art. & sc. ; FIO. Calcutta, 1866-95 ; 331.
Waterlow, pioneer lithographer, c. 1855 ; 329 n.4.
Watermarked paper, 332-4.
Waugh's Manuscripts, 98, 131, 137.
Wazirābād :—Punjab, 52, 209, 296, 337, 524, 539 ; pl. 6.
Waziristan, NWF., W. of D.I. Khān, 48, 216, 501.
Wazirs, Pathān tribesmen, 49, 216, 219, 508.
Weather :—Clear, 42, 46, 83, 100, 116, 132, 203, 212, 543 :—Unfavourable, 14, 23, 25, 27, 38, 46, 52, 55, 83, 114, 117, 175, 188, 204, 206, 223-4, 229, 233, 381, 410, 411, 453, 458, 493, 507-8, 538 :—Variable, 114, 458, 472 ; v. Cold ; Hot.
Webb, Chas. Robt. (b. 1825), civ. asst. Trig., 14 n.1, 19 n.1, 420, 456 :—Geo. Parker Registr., 542-3 :—Capt. Wm. Spencer (1784-1865), Ben. Inf. [III, 512-3] vii 81, 86, 91-2, 136, 542.
Wellesley, FM. Arthur (1768-1852), 1st Duke of Wellington ; *DNB.* [II, 3, 233], xiii.
Wells, 2, 39, 51, 53, 111, 272-3, 459, 478, 493 :—masonry, 259.
Western, James Roger (1812-71), Ben. Engrs. [IV, 474] ; Conolly (88/168) ; Hodson IV, (430-1) ; 374.
Westminster :—Abbey, London, 503 :—School, 512.
Weston, Chas. Thos. Gustavus (1786-1828), Ben. Inf. [III, 513], 529.
Whewell, Rev. Wm. (1794-1866), FRS., 1820, FGS., 1827 ; Trin. Coll. Camb. ; Tides ; *DNB.* ; 69-70.
White :—Ants, or termites, 158, 163, 305 :—wash, 216, 228, 232.
Wilcox, Richd. (1802-48), Ben. Inf. [III, 513-5], vii, ix, 253, 311, 322, 346, 380, 523.
Wild :—Animals, 256, 373, 453, 456, 467-8 ; v. Bears ; Shooting ; Tigers :—Country, 170, 201, 209, 235.
Williams :—David B. (1792-1848) ; Geol. Svy. Gt. Britain, 1839-45 ; GSI., 1845 till death, 142-3 :—Col. Edward (d. 1798), RA., Dir. OS. 1791 till death, 239 :—Henry Wybdham Campbell, civ. asst. Trig., 420 :—M Gen. Sir Hugh Bruce (1865-1942), RE., Lt., 1885, KCB., DSO. ; 543 :—Monier (1777-1823), Bo. Inf., SG. Bombay, 1807-15 [III, 515-6], vi, vii, viii, 221.
Willis, Richd. (b. 1828/9), civ. asst. Rev., 433, 444.
Wilson :—Alfred John (1845-81), Topo. Asst., 432, 434 :—Wm. Alex., his father (b. c., 1806), civ. asst. Rev. [IC, 475], 183, 241, 246-8, 299, 304, 397, 432, 434, 438, 444 :—Wm. Alex. junr., bro. to Alfred, appd. civ. asst. Rev., 1861, 444.
Wind, 14, 32-3, 48, 51, 59, 68, 71, 106, 175, 207, 261, 372, 410, 449, 504, 518, 536.
Wine, 437, 462 :—Merchants, 425 :—Sherry, 411, 462.
Wingate, Maj. Geo. (1802-79), Bo. Engrs. [IC, 475], *DIB.* ; Conolly (105/88), 7, 275-6, 398, 401.
Winsor, Comdr. Geo. O'Byrne (1797-1850), IN., 1810 till death ; Irrawaddy R., 1824-6, *IO Cat.* (120) ; vii, 196.
Wood :—cutters, 105, 207 :—work, 108, 118 ; v. Firewood.
Wood :—Chas. (1842-96), civ. asst. Trig., 344, 420 :—Col. Henry (1872-1940), RE., S of I. 1898-1927 ; *REJ.*, June 1940, 95-6, 237 n.2, 506, 528 :—Lieut. John (1811-71), IN. [IV, 475], xi, 65 n.5, 146, 274, 544 :—John (1845-74), civ. asst. Trig., 344 :—Thos. (1765-1834), Ben. Engrs. [1 : 398-400], 185, 194.
Wood St., Calcutta ; S of I., offices, 352.
Wooded country, 4, 25, 119, 190, 274, 417 ; v. Jungle ; Hills ; Plains
Workmen, 60, 111, 138, 154, 158, 163, 165, 358.
Workshop :—Calcutta (MIO), 76, 149, 162-5, 182-6, 299, 329, 338, 338, 348-9, 351, 358, 533, 536 :—Field, 138, 156, 161, 164 ; v. Mathl. Inst. ; Supt. MIO. ; Telegraph.
Wotherspoon, John (1793-1817), Mad. Engrs., Conolly (98/109) ; viii.
Wounded Officers, 56, 397, 482, 498, 500, 538-9 543 :—Died of Wounds, 455, 493.
Wrangler, mathl. degree, Camb., 381, 520.
Wray, Sgt. Henry (d. June 1873), asst. Rev. Survr., Chota Nāgpur, 1863-4 ; 439.
Wright :—J. B., civ. asst. Mad. Rev., 280, 445 :—T. B., civ. asst. Rev., 444.
Writers, or Clerks, 341-2, 352-3, 365, 446 :—Hd. Writer, 352, 542 :—Buildings, or Sectt., Calcutta, 543.
Wroughton, Maj. Robt. (1797-1850), Ben. Inf. [IV, 476], 8, 123, 162, 164, 179, 241, 244, 266, 295-7, 310, 312, 316, 325, 336, 348 351, 358, 391, 395, 400, 438, 450, 458-9.
Wular Lake, Kashmir, 225-6, 228-9, 490, 493, 514, 518 ; pls. 6, 13.
Wyatt, Alex. (1807-57), Rev. Survr. [IV, 398], 444, 543-4 : his son Alex. Geo. (b. 1845), civ. asst. Topo., 543 :—his bro. Geo. Nevil (1817-57), civ. asst. Rev. [IV, 398], 544.
Wyld, James (1790-1856), cartr., *DNB.* ; vii, 307, 326-7.
Wylie, John Thos. Harris (d. 1854), civ. asst. Rev. Mad., 445.

Yarkand, Central Asia, 76, 146, 232, 237, 511, 528 ; c. 110 m. SW. of Kashgar, (v. pl. 16).
Young :—Archibald Robt. (1804-78), BCS., 1836-62, 242 :—David (b. 1822/3), civ. asst., Bo. Rev., 445 :—G. & J., pro. bros., both civ. asst. Rev., and kd., Jhānsi, 1857, 444, 483 n.1 :—Robt. James (b. 1820), civ. asst. Rev., 266, 444.
Younghusband, Col. Sir Francis Edw. (1863-1942), ISC., KCIE. ; Mason (372) ; *DIB.* ; 92 n.1.
Yusufzai, Pathāns, 215, 475, 488, 505, 508 ; pl. 9.

zamindars, land-holders, 174, 185, 246, 249, 253-4, 260, 263, 300, 451, 463, 473.
Zānskār Range, or R., Ladākh, 88, 205-6, 233-6, 425, 473, 477 ; pl. 6.
Zenith :—Distances, 78, 130 :—Sectors ; Lambton's, 151 :—Strange's, 10, 503, 533.
Zephyr Hall :—Dehra Dūn, 138 :—Mussoorie, 138 n.4.
Zero, change of, 56, 98, 114-6, 119, 121, 132, 155-6, 169, 287, 385, 392.
Zoji La, Kashmir, 227, 233-4, 237-9, 513 ; pl. 13.

Plate 28

INDIA

1861.

Scale 128 Miles = 1 Inch.

Miles 160 140 120 100 80 60 40 20 0 160 320 Miles

REFERENCES

Surveys 1830 to 1861

Red — Principal Triangles of the Great Trigonometrical Survey

Blue — Topographical Surveys

Green — Revenue Surveys

See also plates 3 and 16

Sheets of Atlas of India shown by brown grid, ringed numbers denoting those published by 1870.

Extension to North_East.

Printed at the Survey of India Offices (H. L. O.)